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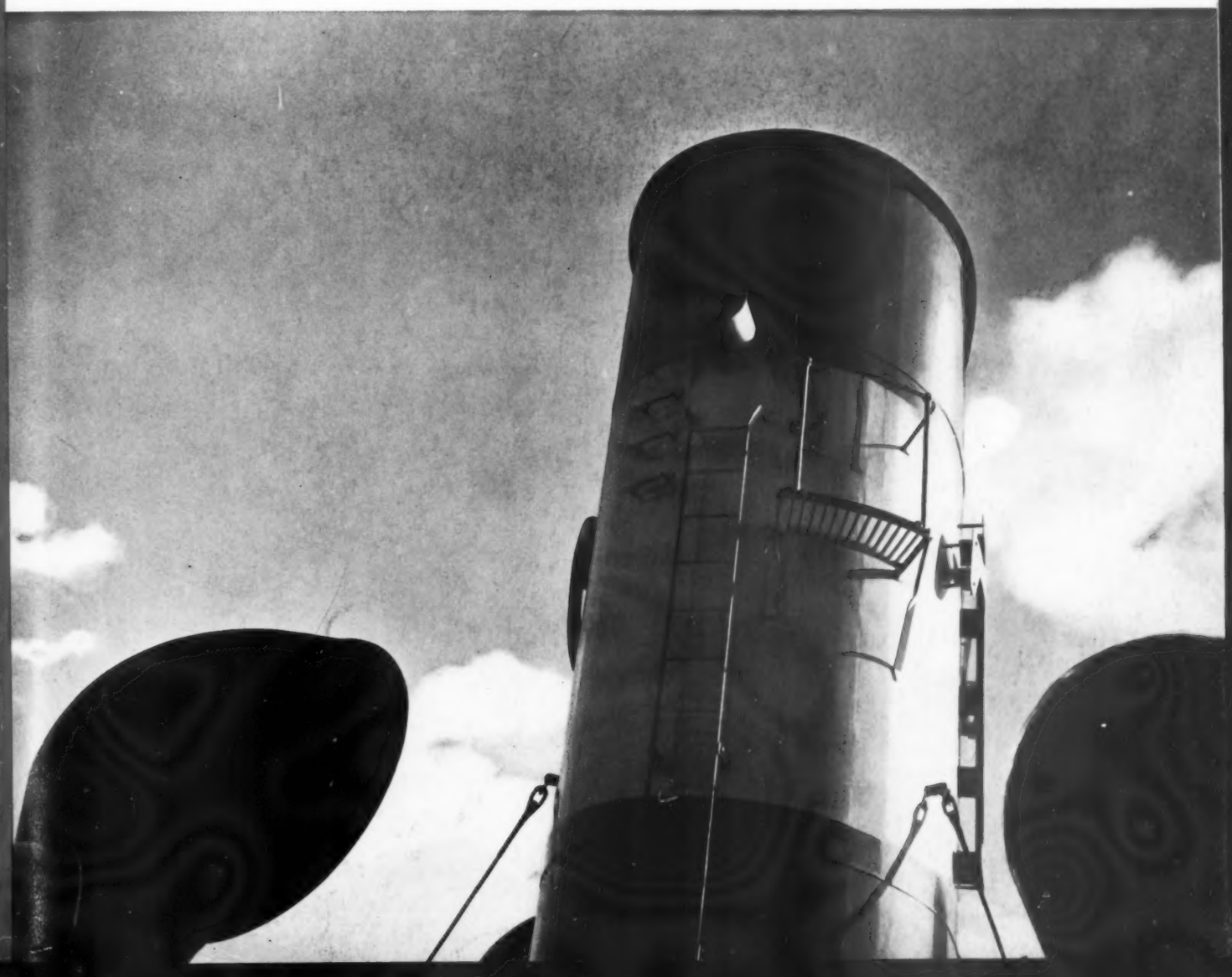
WHAT OF SPAIN'S OIL MONOPOLY?

GEOLOGY AND ECONOMIC SIGNIFICANCE OF ANAHUAC

WORLD TANKER CONSTRUCTION AND REQUIREMENTS

JAPAN'S FAST TANKER PROGRAM



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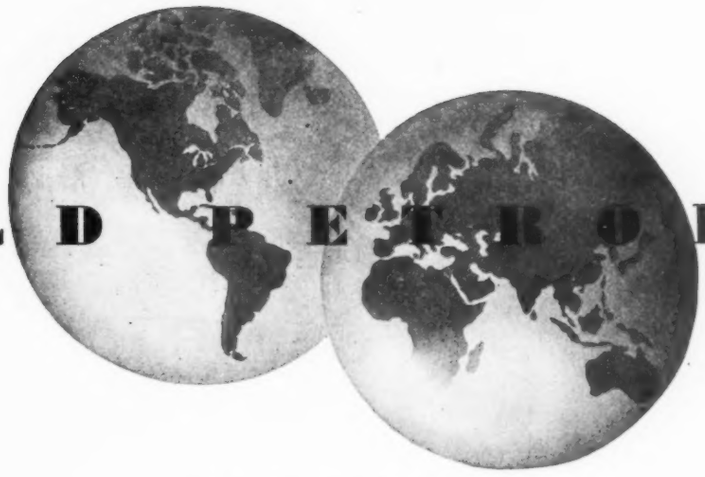

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EDITORIAL

STABILITY—HOW AND WHY?

ONE economic question has stood out in all the discussion of petroleum problems that has gone on during the past four years. It has been at the bottom of the federal administration's efforts to establish a petroleum policy, though the administration itself at different times has been on both sides of the question. It is the fundamental issue in the suits which the Department of Justice is prosecuting against some seventy leading oil companies and oil company officials. It has divided the industry itself into conflicting groups.

The question is whether it is better for the industry and for the country as a whole to have a reasonable degree of stability and of orderly procedure in the oil business or to have it conducted on the basis of reckless and cutthroat competition, with wildly fluctuating prices, unremitting price wars and the business uncertainty and financial ruin of hundreds of well conducted small enterprises that inevitably attend such conditions.

Stated in this form it would seem that there could be only one answer. Yet the fact remains that every effort to establish the conditions and practices prerequisite to that degree of stability prevailing in most other important industries has met with opposition. In part this has come from those who believe, erroneously perhaps, that they can profit individually from the existence of disorder. In part it has come from officials of the government itself, attempting to deal with a business of which they know nothing and concerning which they have not troubled to inform themselves.

WHAT is stability? What does the word mean as applied to business? It connotes a settled orderliness which permits manufacturers and merchants to enter into transactions with reasonable assurance as to the outcome of their undertakings. It depends upon the maintenance of fair and uniform margins for those middlemen who perform a useful function in the processing and distribution of products. The public interest is served by a steady supply of goods at fair prices. It suffers when any group within an industry usurps the power to disrupt markets and to raise or depress prices unduly beyond the limits imposed by fair competition.

On the other hand stability does not premise a static industry. It does not involve complete absence of change. It need not and should not adopt the rigidity of governmental or private monopoly. Relations of supply and demand do fluctuate; improvements in methods of manufacture and distribution effect economies that should be passed on to consumers. In the United States at least, there is a deep seated belief that men of initiative and enterprise should be allowed to profit by the exercise of their abilities and to expand their operations if they can do so without infringing the rights of others.

The problem of all industry is to avoid the static condition that results from too rigid fixation on the one hand and the anarchy of destructive competition on the other, to preserve individual rights and protect the common interest at one and the same time. Neither industry nor government has been able to solve this problem completely, but the system gradually built up in the nations that are most advanced industrially represents the nearest approach to that ideal that has yet been attained.

In the United States the oil industry is highly—even rampantly—competitive. In the past it has suffered incalculable losses from the worst and most destructive forms of competition. Even today it has not fully emerged from this stage of its development though efforts have been made both within and without its ranks to direct it along more orderly pathways. Before real progress can be made the industry must know whether the administration of existing law is to be directed toward the encouragement or the elimination of past disorders and destructive factors.

ENORMOUS losses have been inflicted upon the oil industry and the public through irregular, excessive and wasteful production. Overdrilling has been forced upon oil developers by the legal definition which treats oil as subject to the law of capture, by the demands of royalty owners and by the exigencies of their own financial situation.

To avoid criminal waste in production oil producing states have undertaken to regulate the output of oil within their borders. Since it would be futile for a single state to put restraints upon production if all other states allowed their wells to run wide open the device of an interstate agreement was proposed and has been put into operation under special authority granted by Congress. Its functioning has not been perfect but it has been a stabilizing factor in crude production. It has worked well enough so that sentiment of a great majority of the industry is strongly in favor of an extension of the compact for another period of years though an active campaign of opposition is being waged by one marketing organization.

Evasion of state proration laws led to the enactment of

another federal law prohibiting the movement in interstate commerce of oil produced in excess of state allowables. This has been an aid to stability in the crude oil situation by adding to the efficiency with which state laws can be enforced. This again is a measure which has demonstrated its usefulness to the point where sentiment both in the industry and in official circles favors its continuance.

TRADE'S OWN OBLIGATION

STABILITY, however, is not merely a matter of legislation. It depends upon the maintenance of sound and fair practices within the trade. It requires a reasonable, not necessarily an absolute, uniformity of prices. There must be likewise a practical uniformity in the margins, discounts or commissions allowed to middlemen and retailers. In most lines of business custom has long since determined what price-spread or commission the broker, jobber and wholesaler shall receive. The manufacturer who attempts to stimulate the sale of his product by allowing better than the customary terms to dealers directly encourages the latter to broaden their own operations by more or less extensive price cutting. Competitors soon feel the effect and move to defend themselves. A price war is quickly under way; goods are sold for less than the cost of production; the conflagration continues until all concerned, or at least all who are not wiped out, feel that they have taken sufficient punishment. Then they go back to the normal basis of conducting trade.

The spectacle is a familiar one in the oil industry for there is scarcely any other kind of business where price wars have been so frequent, so fierce and so costly. They benefit no one; even the consumer who gets the temporary advantage of abnormally low rates usually has to make up for it in higher costs later on. They disrupt industry, ruin dealers who adhere to legitimate trade practices and have cost the oil industry—producers, refiners and marketers—a sum that runs to incalculable millions. Yet so contradictory is human nature that major oil companies, through the terms granted to distributors, have repeatedly furnished the ammunition used in carrying on such destructive competition against themselves. In the public interest this practice should be discouraged. Certainly it should not be forced upon the industry as the only means of avoiding legal penalties.

Another factor in maintaining stability is the handling of purchases. Many of the oil companies supplying broad markets are regularly engaged in buying products as well as crude oil to meet the demands of their trade. Sometimes prices are so low that they buy largely in the open market in preference to drawing upon their reserves. At times they buy beyond their immediate needs in the belief that rising prices will net them a profit. Many did this in 1928 and 1929 and paid for their mistaken judgment in heavy losses incurred later. Now and again they extend their purchases in order to absorb distressed offerings that otherwise might disorganize the market. This procedure was particularly urged upon the major companies in the period following the downfall of the NRA and the Petroleum Administration's loss of the powers which it had exercised temporarily. The practice is a legitimate one and is at times essential to the maintenance of market stability.

EVERY game has its rules and the means of enforcing them. Every state and local community has enacted laws to protect its citizens in the enjoyment of their established rights and to prevent them from encroaching upon the rights of others. Where the authority of the state ends or where state interests may clash the federal government intervenes to enforce and to protect. As social conditions change and economic relations become more complex the laws and regulations that were adequate for a past period may require change to meet today's situation. In a rapidly expanding and changing industry like petroleum it is not surprising that legislation has failed to keep pace with the transformation that has taken place or that practices which seemed permissible when the business was of small economic consequence are indefensible now that oil enters into almost every phase of industry and is an indispensable factor in our daily life.

In the oil industry there is and has been no lack of competition. There are and have been grave wrongs perpetrated through unfair and destructive competition. There is no need to prosecute men for striving to bring order out of chaos or to incite them to practices that involve waste of the nation's resources and destruction of the rights that all should enjoy in common. There is need to encourage by law and by the application of the law fair competition, fair dealing and a fundamental stability in this industry which vitally affects so many others and on which so vast a segment of the country's population are dependent for employment, efficiency and comfort in their daily lives.

WORLD DEPENDENCE ON TANKER EFFICIENCY

SO MUCH of the world's oil supply is found at great distances from the places of principal demand that transportation has a vital part in the functioning of the industry. As petroleum has come to play a more and more essential role in industrial operations and in national defense ocean transport, both of crude oil and its products, has become increasingly important.

Twenty years ago tankers represented a scant five percent of all powered vessels, about 2,000,000 gross tons. Today, with the tonnage afloat and under construction approaching the 10,000,000 mark they comprise nearly 15 percent of all shipping. The largest commercial fleets are the tanker fleets of the great international oil companies. Supplementing these is a vast tramp tonnage. Their routes girdle the globe and criss-cross the ocean highways in all directions. Without their constant service navies would be rendered helpless, a great proportion of the ships now engaged in commerce would be tied up and many lines of industry would be brought to a standstill.

With the growth in the size and number of tankers, in the importance of the function they perform, and in the specialized services they are called upon to render, many technical and commercial problems have developed. Questions of design and construction, of speed, of rapidity in loading and discharging cargo, of economical operation and of safety, have arisen. Great progress has been made, many improvements have been introduced, but the final answer to some of the questions propounded in the past, and of new ones arising as conditions change, is still to be given.

Because of the tanker's significance, not only to those directly engaged in oil transportation, but to everyone connected with the production and marketing of petroleum in any form, WORLD PETROLEUM is devoting a large section of this issue to a review of construction activities and operating conditions and to a consideration of some of the problems affecting its future development. At a time when the demand for ocean transport of oil is greater than ever before the subject, we feel, is one of particular interest.

WHAT OF SPAIN'S OIL MONOPOLY?

By Ake K. Ranch

Costly Record of Campsa and Urgent Need of Revenue Confronting New Government Suggests Probable Return to Private Operation if Not to Free Competition

ON JULY 11th of last year, two days before Calvo Sotelo, the Spanish monarchist leader, was murdered and the signal thus given for the beginning of the terrible civil war which is still raging throughout Spain, the AÑUARIO DEL MONOPOLY DE PETRÓLEOS left the press. In this 482-page volume the balance sheet for 1935 operations of CAMPSA, the Spanish petroleum monopoly, is presented to the public. This report enables one to analyze the financial results of the state monopoly during a period when normal conditions still reigned in Spain, though the book by no means presents an accurate picture of CAMPSA'S actual state of affairs. In Spain there always has been a great deal of mystery attached to the petroleum monopoly, but the popular conception is that, as a business proposition, the monopoly is sound and profitable to the nation. To determine to just what degree this popular conception is correct is the purpose of this article.

In glancing through the AÑUARIO DEL MONOPOLY DE PETRÓLEOS it soon becomes evident to the observant reader that its object is to defend CAMPSA at any price and to prove the superiority of monopoly over free competition as far as petroleum is concerned. This proves a difficult point to put across convincingly, but the report attempts to impress the reader with glowing reports of the income the Spanish Treasury has derived from the monopoly. Nothing, however, is said about its disadvantages to motorists, the government, and the country as a whole. No mention is made of the higher prices, lower quality, poor service, and decreased revenue from other sources.

It can be hardly considered logical to try to prove the excellence of monopoly by pointing out that for 1935 CAMPSA paid a dividend of 9.03104 percent. The results of the company's activities have no bearing on its right to be a monopoly. It is true that CAMPSA is the owner of all installations, buildings, tankers and other equipment, but the company does not work on its own account but on that of the government. Thus an account is rendered of takings and costs, the latter including depreciation. As remuneration CAMPSA receives a fixed sum every year, corresponding to the guaranteed five percent dividend, in addition to four percent of its net takings on sales.

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Spanish loyalist on the barricades outside Madrid.

Preparing a field piece in the Spanish civil war: whichever side is victorious, the Spanish Oil Monopoly in its present form is likely to be dissolved.

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A motor car that will no longer require the precious petrol now distributed by Campsa under strict limitation.

According to a special account labeled "Administration of the Monopoly for 1935", the government had a credit balance of 286,544,693.44 pesetas at the end of the year. It further received 4,063,968 pesetas in dividends on the shares it was given by CAMPSA as payment for the monopoly, and 56,519,943 pesetas from a special gasoline tax of 10 centimos a liter. Thus the total credit balance was 347,128,604.44 pesetas at the end of 1935. This is, of course, a very substantial sum, but one must not be misled by it into immediately deciding that monopoly is more favorable than free competition. It is certainly worth calculating just how much income free competition would have netted the government for the same period, but in this connection one looks in vain for any guidance in the Year Book.

Since April 1, 1932, the price of "Gasolina Auto" has been 76 centimos per liter in all parts of Spain. Before the establishment of the monopoly gasoline prices varied according to transport conditions, and prices often fluctuated a centimo or two in the same locality. Prices prevailing in June, 1927, however, represent a fair average for the entire year in question. In Barcelona the price was 38 centimos a liter, at Sevilla 42 centimos, and in Madrid 48 centimos per liter. The average price, calculated on the basis of the quantity sold in 1927, did not exceed 43 centimos per liter. If the same conditions of free competition had existed in 1935, there seems to be very little doubt that prices would have been considerably *lower* than the 1927 average, instead of higher as under the monopoly. It certainly is not unfair to the monopoly to compare costs and freight for the two years.

The official quotation for 61–63 deg. gasoline f.o.b. Gulf in June, 1927, was 7.891 (U.S.) cents per gallon of 3.78 liters. With the rate of exchange then ruling (5.804 pesetas = $1) the price was 12.12 Spanish centimos per liter. The 1927 average freight from Gulf to Spain was £1.11 per metric ton. At a rate of exchange of 28.197 pesetas = £1, the freight amounted to 4.37 centimos per liter, and the gasoline price c.i.f. Spanish port can be fixed at 16.49 centimos per liter. For June, 1935, with a quotation of 5.2344 cents per gallon and freight of £0.13 per ton (exchange rate: 7.345 pesetas = $1 and 36.2270 pesetas = £1), the corresponding figure is only 12.52 centimos per liter—a difference of 3.97 centimos.

Further, if contracting for large quantities a certain discount is obtainable. The significant point here, however, is not so much the actual selling price but the definite trend toward a lower cost price. Moreover, it must be remembered that the gasoline formerly supplied by private oil companies was not the miserable "Gasolina Auto", but rather the "Gasolina Avion", which costs 10 centimos more. And we have not taken into consideration the discounts and "restitutions" which were once available from the competing companies in Spain without too much arguing. But putting all these factors aside, it will still be easy to prove that financially the monopoly is not a sound enterprise. It can thus be said that under any circumstances, in the case of free competition, the price would have been at least four centimos lower than in 1927, or 37 centimos cheaper than the price fixed by the monopoly.

In this connection it may be of interest to compare the price development in Spain with that in another European country of roughly the same size and number of motorists, but which retains free competition—Sweden. In Stockholm, for example, the price of gasoline was 32 öre per liter in June, 1927, and 27 öre per liter in June, 1935. After deducting the special gasoline tax (which in 1927 was 5 öre per liter, but since May 1, 1932, has been 10 öre) these figures become 27 öre and 17 öre, respectively. Converted into Spanish currency (on the basis of 100 pesetas = 64.61 Swedish Crowns in June, 1927, and 100 pesetas = 54.27 Swedish Crowns in June, 1935) this amounts to 41.79 and 31.32 centimos per liter, respectively. Keen competition in Sweden, especially from Russian products, is chiefly responsible for this decrease. A corresponding influence could have been expected in Spain, had not the monopoly prevented it.

In order to ascertain the degree of efficiency with which the monopoly is operating, it is necessary to estimate how much the Spanish Treasury would have received under free competition if the customs duties on the monopolized products had been increased to such a rate that retail prices equaled those now fixed by CAMPSA. The difference in the price of gasoline under CAMPSA and free competition, which has already been estimated at an absolute minimum of 37 centimos per liter, multiplied by the quantity of gasoline sold in 1935 (580,419,000 liters), gives a sum of 214,755,030 pesetas. Before April 1, 1932, however, there were local gasoline taxes in certain parts of Spain. Now they are abolished and the government compensates the municipalities in question with a total of 8,279,342.68 pesetas. This sum must, of course, be deducted from the above-mentioned amount, but this still leaves 206,475,687.32 pesetas of potential customs duties lost by the Spanish Treasury.

The price of kerosene has been raised from 43 centimos per liter in 1927 to 75 centimos per liter in 1935, a rise which with the 1935 consumption of 21,114,720 liters amounts to 6,756,710.40 pesetas. The price of gas oil has been increased 8 centimos (from 32 to 40), which with a 1935 consumption 143,257,450 liters equals 11,460,596 pesetas. From this sum, however, must be deducted 3,262,623.60 pesetas, discounts given to Spanish fishermen, leaving 8,197,972.40 pesetas. Prices of lubricating oils, paraffin, and vaseline have been increased as shown in the table.

It would certainly be most interesting to study how much the various other monopolized products (ether, benzole, Diesel oil, fuel oil, asphalt, etc.) have risen in price, and for how much of the profits of the monopoly these excess prices are responsible.

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War scene from Spain where not only the political system, but the social and economic organization is undergoing violent transformation.

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Through the delapidated remains of a Spanish house machine guns are trained on the Spanish Nationalist forces.

Being such a difficult question, though, it is preferable that it be omitted from this calculation. Of the products studied, only the increase in retail prices has been considered and, with the exception of gasoline, decreasing cost prices have not been taken into account. In this matter, too, it is difficult to get exact figures, and nothing can be done without jeopardizing the value of the entire calculation.

monopolized products, CAMPSA has the privilege of importing—duty-free—pumps, and other equipment which cannot be manufactured in Spain. Unfortunately, it is impossible to estimate the amount and value of these articles which would have been bought by the private oil companies, or the revenue which would have been obtained by the government. Further, CAMPSA is exempt from taxation. Before the establishment of the monopoly the Spanish Treasury received some 20,000,000 pesetas annually in taxes from the oil companies. Gasoline sales, which were 277,500,000 liters in 1927, rose to 569,000,000 liters in 1935. Is there anyone who doubts that, with sales more than doubled, the companies would not have been able to double their profits?—resulting in a more than proportionate increase in taxes? An estimate of 40,000,000 pesetas in taxes lost to the government can by no means by considered too much. The accompanying table lists individually and totals all of the above-mentioned losses to the government.

Thus it can be seen from this table that for 1935 the Spanish Government could have secured at least 172,000,000 pesetas more under free competition than actually received from CAMPSA. The establishment of the Spanish Petroleum Monopoly has led to an unparalleled waste of the nation's money. This fact, however, is by no means as well known in Spain as it deserves to be. People are easily misled by the published "results" of the statements, and with the proverbial care-free attitude of the southerners, they (generally speaking) do not bother to probe the fundamentals of the problem. But, of course, there are some who did, and once the poor economic results were evident the monopoly enthusiasts asserted that it was only a temporary phenomenon—more or less common to all new enterprises. It may be true that for 1935 the yield is better than in previous years, but considering that the company started its activities in 1928, it is evident that it could not have come much further in "efficiency."

If further pressed the monopolists may admit that the monopoly is not very favorable to the government, but contend that, on the other hand, the nation as a whole is benefiting. Thanks to the monopoly, they say, refining activities have been initiated which private companies would not have cared to undertake, resulting in greater employment of labor. Nevertheless, the writer strongly disagrees with this line of thought, for through this policy the resources and efforts of the nation are artificially attracted into an industry for which it has no qualifications. Economic expansion in Spain's natural fields of endeavor is thus made more difficult owing to lack of capital, enterprising spirit, and really skilled labor.

But why, then, has the petroleum monopoly in Spain not been abandoned, and the 20-year contract between CAMPSA and the Spanish state canceled? To begin with, in 1931 a bill was prepared providing for a return to free competition, but it was never presented in Cortes, the Spanish parliament. The powerful financial groups behind CAMPSA, whose investments would be practically wiped out in the event this reform was realized, have always managed to exert sufficient influence in the proper quarters. Furthermore, the political situation in Spain has always been too delicate for any government to chance increasing the number of its antagonists among people directly or indirectly interested in the existence of the monopoly. To some extent CAMPSA owes its existence to sentimental reasons, as it was instituted by General Primo de Rivera, the Spanish fascist dictator. Partly for this reason, the conservatives would not eliminate it, while on the other hand the monopoly suited only too well the socialist program of state-management of important activities. And so it can be seen that it would have been quite difficult to change the *status quo* of CAMPSA. Spain, moreover, has had far more important problems confronting her. Thus the monopoly seemed to have become a perpetual institution when the civil war broke.

In the areas controlled by the red forces, CAMPSA—though in a modified way—still handles the buying and distribution of gaso-

(Continued on page 90)

Increases in Prices

	Increase	Sales in 1935	Amount (in pesetas) Spanish Treasury would have received
Lubricating oils	80 ptas./100 kgs.	32,185,199 kgs.	25,748,159.20
Paraffin	85 ptas./100 kgs.	6,483,582 kgs.	5,511,044.70
Vaseline	110 ptas./100 kgs.	1,408,954 kgs.	1,549,849.40

It is, of course, impossible for an outsider to know how much CAMPSA has saved by supplying products of inferior quality (as everyone knows it does), but a fairly accurate estimate would be at least 5,000,000 pesetas during 1935. The gasoline retailer's margin of profit has been slashed, too, and this must be entered to the debit of the monopoly in our calculations. Before the establishment of CAMPSA retailers received an average of 7.5 centimos per liter—now they receive barely 2.5 centimos per liter. The difference totals 29,020,950 pesetas on the 1935 sales of 580,419,000 liters.

We must not confine ourselves to a discussion of the excessive prices consumers have had to pay, but must also take into consideration revenue which, thanks to the monopoly, the Spanish government has failed to receive. First of all, according to the CAMPSA Year Book, the Spanish Treasury during 1935 would have received 191,499,-920.74 pesetas in customs duties on imported petroleum products under the old system of free competition. And, in addition to the

Minimum Losses Sustained by Spain Through Operations of Petroleum Monopoly

Excess retail prices:		
Gasoline (inclusive decreased cost price)	206,475,687.32 Ptas.	
Kerosene (exclusive " " ")	6,756,710.40 "	
Gas Oil (" " " ")	8,197,972.40 "	
Lube Oils (" " " ")	25,750,159.20 "	
Paraffin (" " " ")	5,511,044.70 "	
Vaseline (" " " ")	1,549,849.40 "	
		254,241,423.42 Ptas.
Inferior qualities		5,000,000.00 "
Gasoline retailers confiscated profit		29,020,950.00 "
Receivable customs-duties on monopolized products, according to CAMPSA		191,499,920.74 "
Lost taxes		40,000,000.00 "
Total		519,762,294.16 "
Revenue (1935) from CAMPSA monopoly		347,128,604.44 "
Difference in favor of free competition		172,633,689.72 "

GEOLOGY AND ECONOMIC SIGNIFICANCE OF ANAHUAC

By Michel T. Halbouty and J. Brian Eby

Eighth of a Series of Articles Dealing With the Geology, Reserves and Economy of the More Important Oil Fields Throughout The World.

THE ANAHUAC oil field, one of the most important Gulf Coast oil discoveries in recent years, lies in north central Chambers County, Texas, six miles east of Anahuac, the county seat, and about forty-five miles due east of Houston and the same distance southwest of Beaumont. In an air-line the field is about twenty-five miles from the coast.

From the discovery of the field in March 1935 to the end of January 1937, the productive area has spread steadily until it now covers about 7500 proven acres. The field centers around the four surveys, the J. R. Curl No. 52, the H. & T. C. R. R. No. 57, the H. & T. C. R. R. No. 51, and the A. D. Middleton No. 58, page 50. At least twelve other surveys surrounding the foregoing are now producing oil. Twelve dry holes have approximately established the ultimate extent of the field in all directions. Within the field by February 1, 1937, there were 142 producing oil wells.

The general shape of the field is circular. Faulting, however, has greatly affected the producing sands and the actual pattern of the productive area is quite irregular. Development so far has extended production slightly over four miles in a north-south direction and from three to four miles irregularly in an east-west direction. This large productive area ranks Anahuac as one of the most extensive fields in the Gulf Coast, surpassed only by the 17,000 acre Conroe field.

The Humble Oil and Refining Company control about 85 percent of the field. The remaining acreage is divided between the Gulf Oil Corporation and the Sun Oil Company. Glenn H. McCarthy, Houston independent operator, who, with R. A. Mason, drilled the discovery well for the great northward extension of the field, late in 1936, sold out his operating interest to the Humble, leaving the field entirely in the hands of the major oil companies. The land ownerships are in large tracts and few owners. There are no cemeteries, townsites or minor subdivisions, with the exception of a single acre school site, the oil rights to which were acquired by the oil companies owning the contiguous leases. This situation has permitted an orderly methodical twenty-acre-per-well development.

The actual discovery of oil was preceded by a long series of geophysical investigations by various companies. Due largely to the depth of the structure and its broad extent and gentle folding, it was a difficult task to locate and detail correctly by geophysics. The area was shot by refraction seismograph and investigated by torsion balance and a prospect was indicated in 1933 and 1934. In the latter part of 1934, the Humble Oil and Refining Company, having acquired a block of leases, proceeded to use the reflection seismograph to detail the area. Following this work, the A. D. Middleton, No. 1 well was located and drilled. It proved to be the discovery well of the field.

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The second well of the field was the Clark No. 1, west offset to the discovery which was completed April 3, 1935. This well was drilled to a total depth of 7117 ft. and completed a producer. The south offset and southwest offset wells, the J. E. Broussard No. 1, and A. D. Middleton No. 2, respec-

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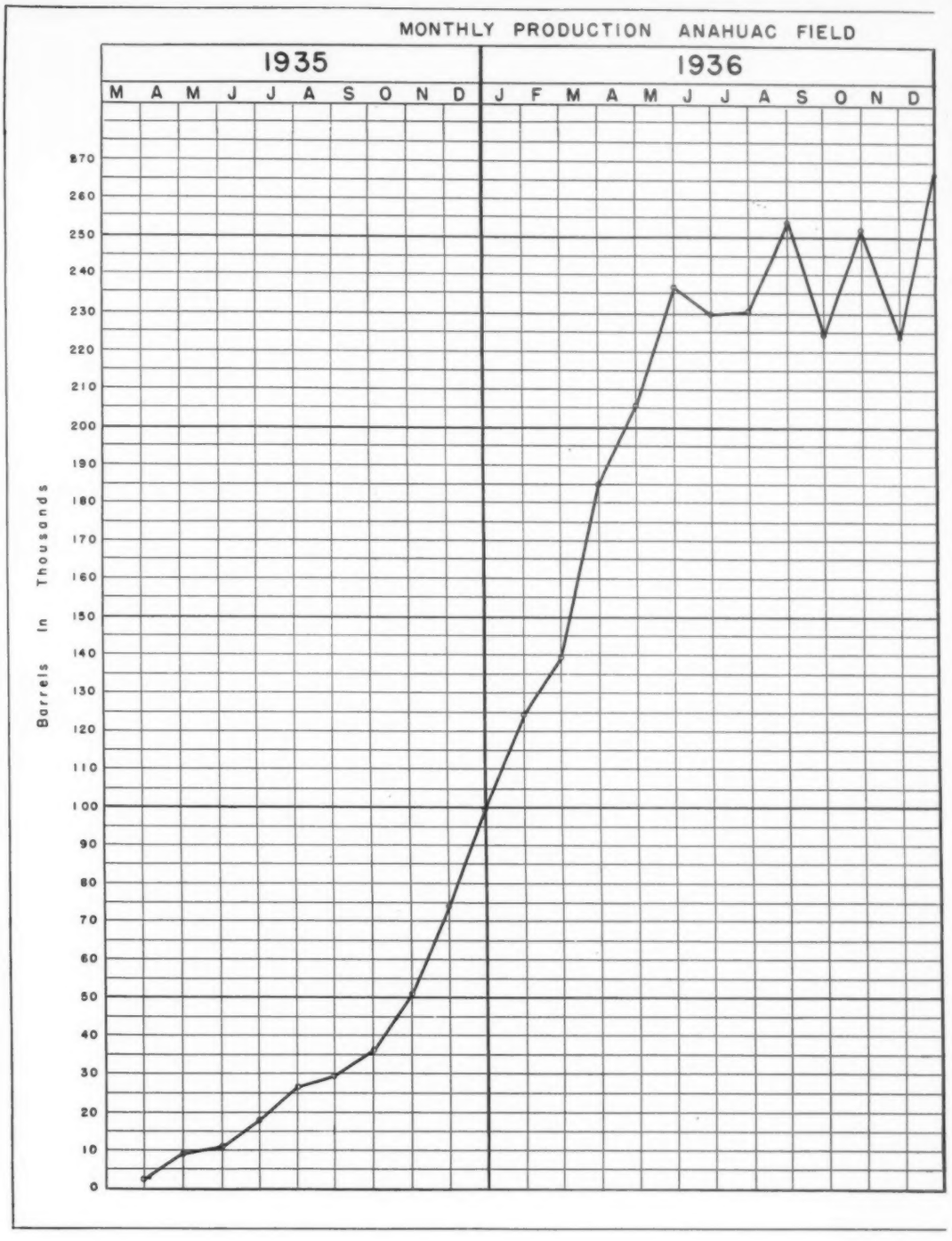

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The far northeast extension of the field was established by the Humble's E. W. Boyt, No. 1, on August 15, 1936, which drilled into seven feet of producing sand from 7122 to 7129. By the close of 1936 the general limits of production were fairly well defined, proving up one of the largest oil fields in the coast.

Topographically the field is flat and for many years had served for rice farming. The surface soil for the most part is black loam and when rained upon becomes impassable. Shortly after the discovery of oil the question of transportation became of utmost importance. With wise forethought the major operators of the field, principally the Humble, laid out their own road system. At the time of this writing there are over 35 miles of company owned road graded and heavily shelled, offering all weather transportation of the field.

STRATIGRAPHY

The Beaumont clays at Anahuac outcrop on the surface and they range in thickness from 20 to 50 ft. The clays are compact and dark gray to black.

The Lissie formation of Pleistocene age underlies the Beaumont clays and its appearance is marked by the vast sand break encountered below the Beaumont clays. The Lissie formation is characterized by sands, sands and gravels, shales, and sandy shales, and large bodies of sand and boulders intermingled with sandy shales. Numerous water sands in this formation are encountered. The thickness of this formation at Anahuac is approximately 1200 ft.

The Upper Pliocene formation, which is the Citronelle, lies underneath the Lissie formation and is characterized by nodular calcareous shales and limestones. The thickness of this formation is approximately 800 ft.

The Lower Pliocene formation or Upper Fleming lies underneath the Citronelle and contains sandstone and limestone ledges interassociated with sandy shale and shales. This formation is approximately 1000 ft. thick.

The Upper Miocene formation or Lower Fleming is composed of limestones and green compact shales, intermingled with fine-to-medium-grained sands and gray sandstones. The top of this formation is easily identified by the paleontological guide *Potamides matsoni*, which is placed in the section at the extreme top of the Upper Miocene.

Underlying the Upper Miocene is the *M Dv* zone which is approximately 250 ft. thick and is mainly sands and sandy shales. This zone is characterized by the appearance of inter-association of *Discorbis cf. D. vilardevoana* D'Orbigny and associated fauna with *Rotalia beccarii* (Linne) D'Orbigny and associated fauna.

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GEOLOGY AND ECONOMIC SIGNIFICANCE OF ANAHUAC

By Michel T. Halbouty and J. Brian Eby

Eighth of a Series of Articles Dealing With the Geology, Reserves and Economy of the More Important Oil Fields Throughout The World.

THE ANAHUAC oil field, one of the most important Gulf Coast oil discoveries in recent years, lies in north central Chambers County, Texas, six miles east of Anahuac, the county seat, and about forty-five miles due east of Houston and the same distance southwest of Beaumont. In an air-line the field is about twenty-five miles from the coast.

From the discovery of the field in March 1935 to the end of January 1937, the productive area has spread steadily until it now covers about 7500 proven acres. The field centers around the four surveys, the J. R. Curl No. 52, the H. & T. C. R. R. No. 57, the H. & T. C. R. R. No. 51, and the A. D. Middleton No. 58, page 50. At least twelve other surveys surrounding the foregoing are now producing oil. Twelve dry holes have approximately established the ultimate extent of the field in all directions. Within the field by February 1, 1937, there were 142 producing oil wells.

The general shape of the field is circular. Faulting, however, has greatly affected the producing sands and the actual pattern of the productive area is quite irregular. Development so far has extended production slightly over four miles in a north-south direction and from three to four miles irregularly in an east-west direction. This large productive area ranks Anahuac as one of the most extensive fields in the Gulf Coast, surpassed only by the 17,000 acre Conroe field.

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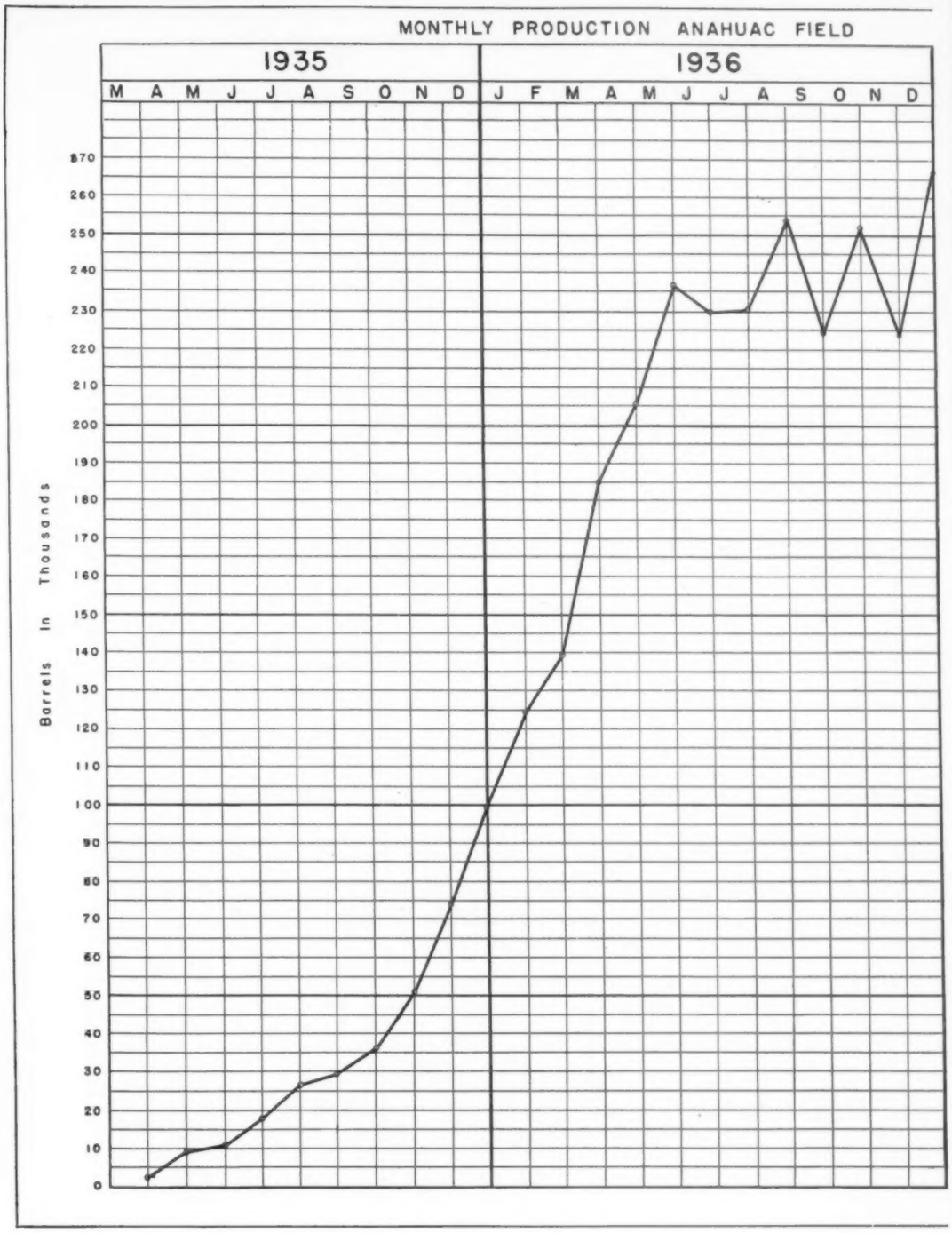

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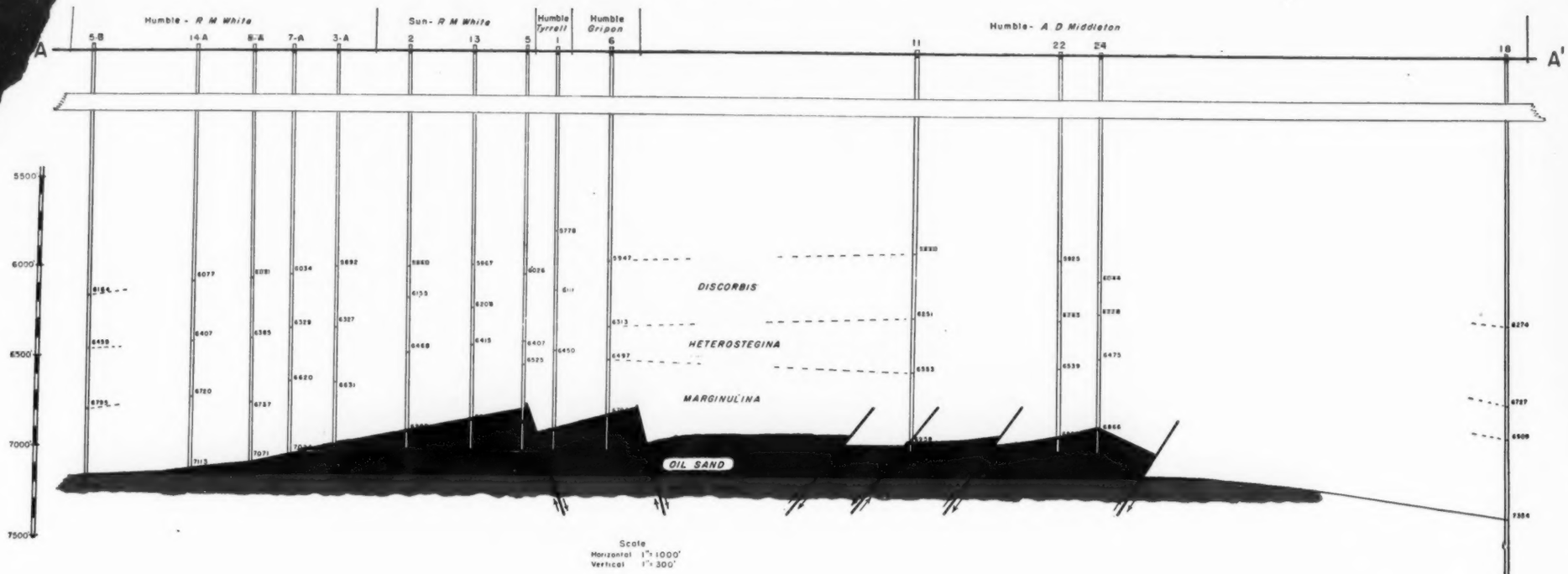
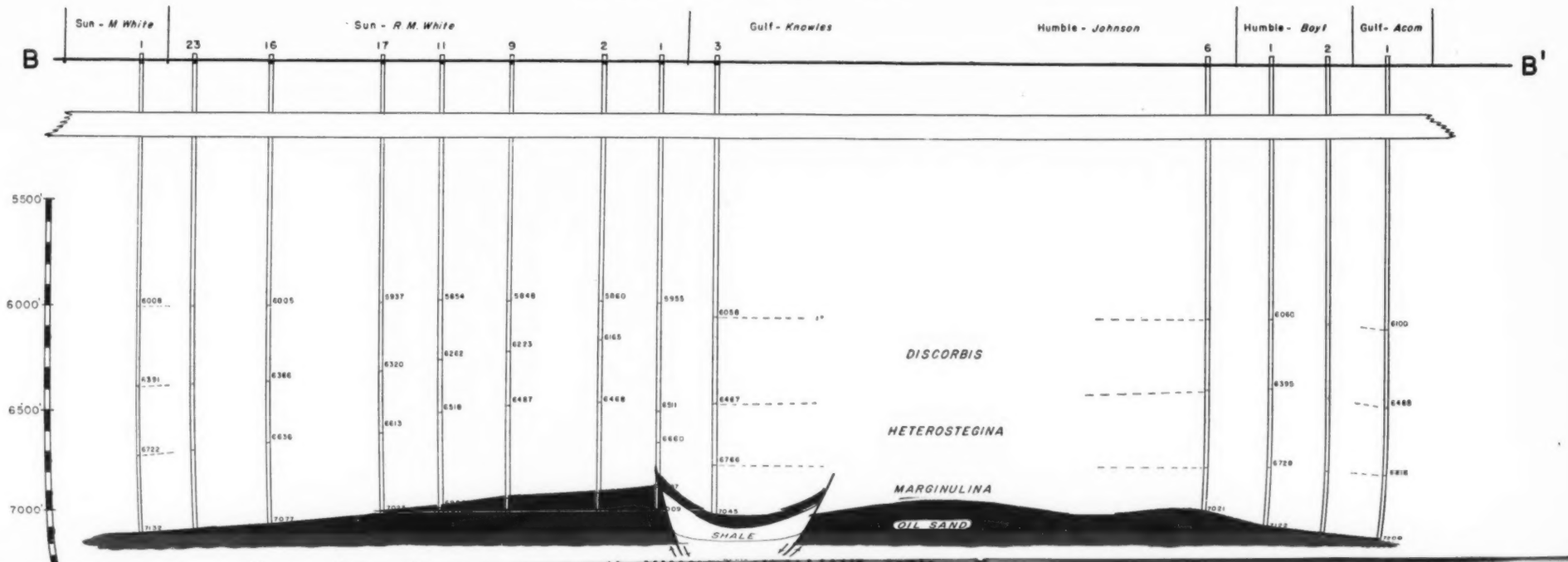
CROSS SECTION A-A'



CROSS SECTION B-B'



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CROSS SECTION D-D'

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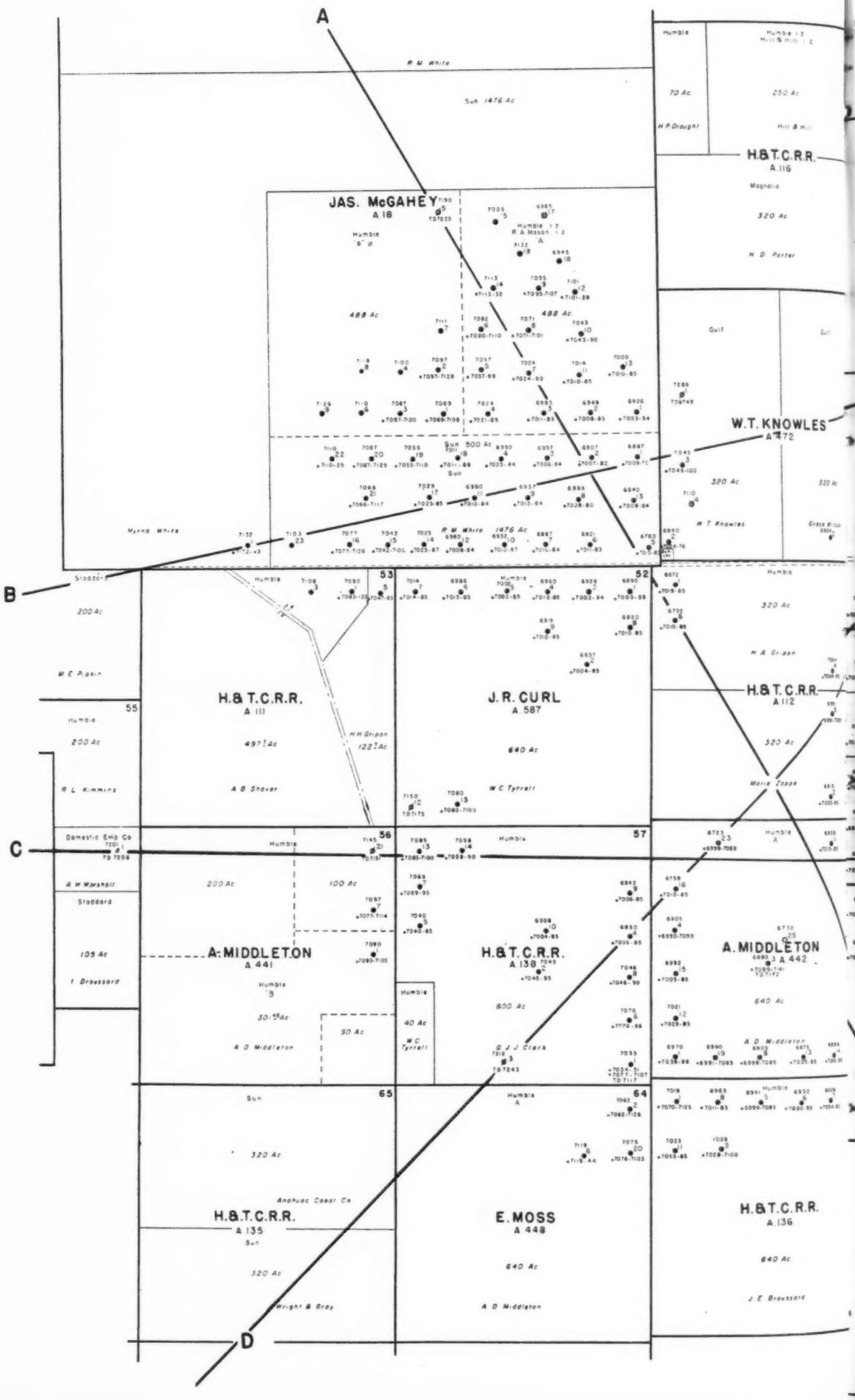
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J.R. CURL
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E. MOSS
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A 136
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Humble
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250 Ac
H.P. Draught
Hill & Hill
Magnolia
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H.D. Porter
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Gulf
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Sun
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1476 Ac
W.T. Knowles
Grace Ellis
Stoddard
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Maria Zappe
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A.W. Marshall
100 Ac
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I. Broussard
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G.J.J. Clark
A.D. Middleton
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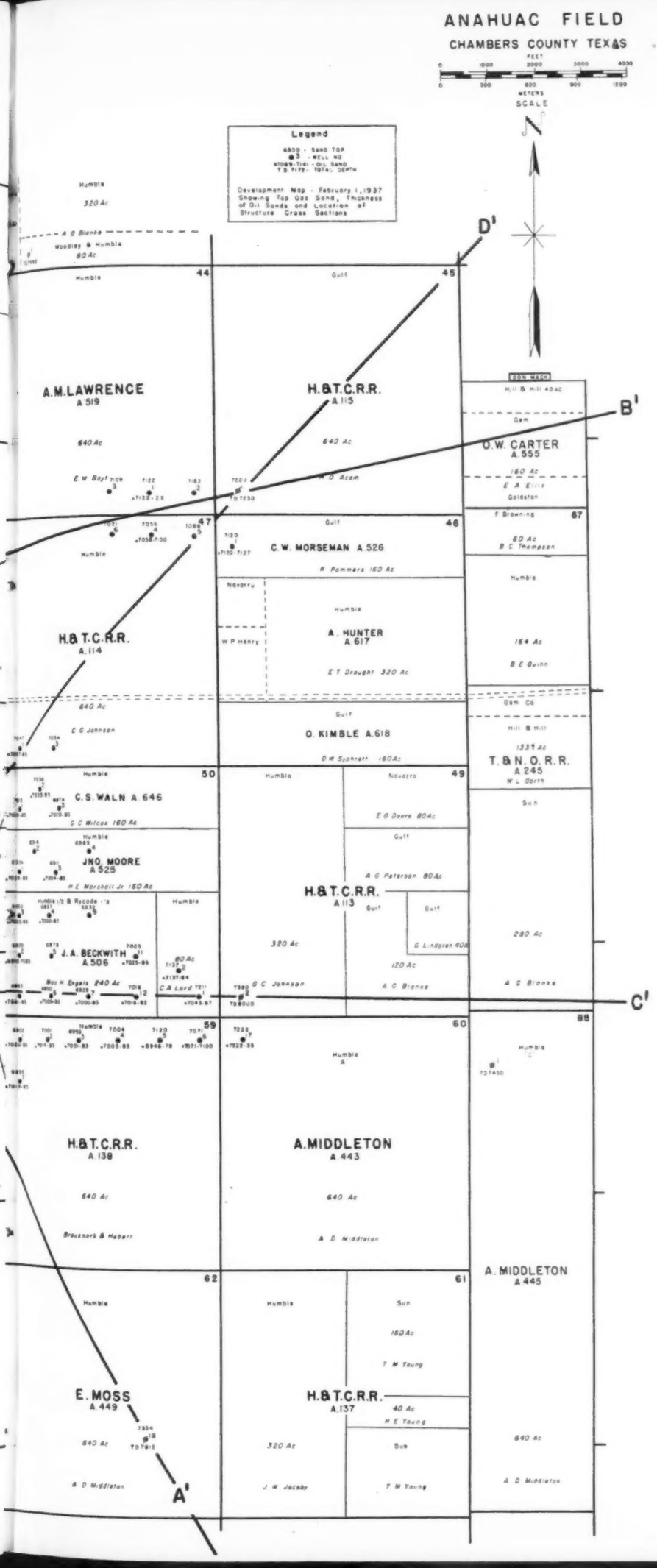
Anahuac Canal Co
Wright & Gray
J.E. Broussard



and prominent, which marks the top of this *Discorbis* zone. The zone is characterized chiefly by shales and sandy shales. The thickness of the *Discorbis* zone is from 300 to 400 ft.

The *Heterostegina* zone of Middle Oligocene age is distinguished by the entrance of the *Heterostegina antillea foraminifera* and the zone is characterized by hard calcareous shales and limestone. The thickness of this zone is from 300 to 350 ft. Underneath the *Heterostegina* zone is the *Marginulina* zone of Middle Oligocene age, which is identified by the entrance of *Marginulina* zone foraminifera definitely marked by *Marginulina cf. M. philippinensis*. Underneath the *Marginulina* zone the Frio formation of Lower Oligocene is penetrated. The Frio sand is the main productive sand at Anahuac. The gas sand is entered into before the penetration of the oil sand and this gas sand is approximately in its maximum thickness 284 ft. The oil and gas contact is approximately at 7007 ft. The Frio sand is fairly coarse-grained, requiring .010 gauge screen. The gas cap sometimes in some areas in the field is very indurated and resembles hard sandstone, however, the oil sand is not so indurated but is a firm consolidated sand.

SUBSURFACE GEOLOGY

The Anahuac oil field is considered to be a deep seated salt dome structure, known as the non-piercement type of dome, with the curvatures of the formations forming a regular dipping pattern, marked and broken by many faults, and with a maximum uplift of 850 ft. above normal. The structure is relatively a circular one, as far as represented proven acreage is concerned, but very irregular in its actual shape. Just after the discovery well was brought in, it was believed that the field would be a regular sized Gulf Coast field with an extent of approximately four square miles centering around section 58. The geophysical picture substantiated this belief but the many faults affected the geophysical interpretation in throwing a closure where in reality there were minor faulting, and which were not proven otherwise until the White No. 1 extension well was drilled to the north by McCarthy, et al.

The Sand Contour Map, page 52, clearly shows the number of faults in the field and by studying this figure it is very noticeable that there are three systems of faulting. One system runs north and south, another east and west, and the third northeast and southwest. One of the major faults cuts across the James McGahey survey but the upthrow side to the west. A component fault cuts across the W. T. Knowles survey but the upthrow to the east. These two faults form a graben in which the Frio sand has been lowered below water level.

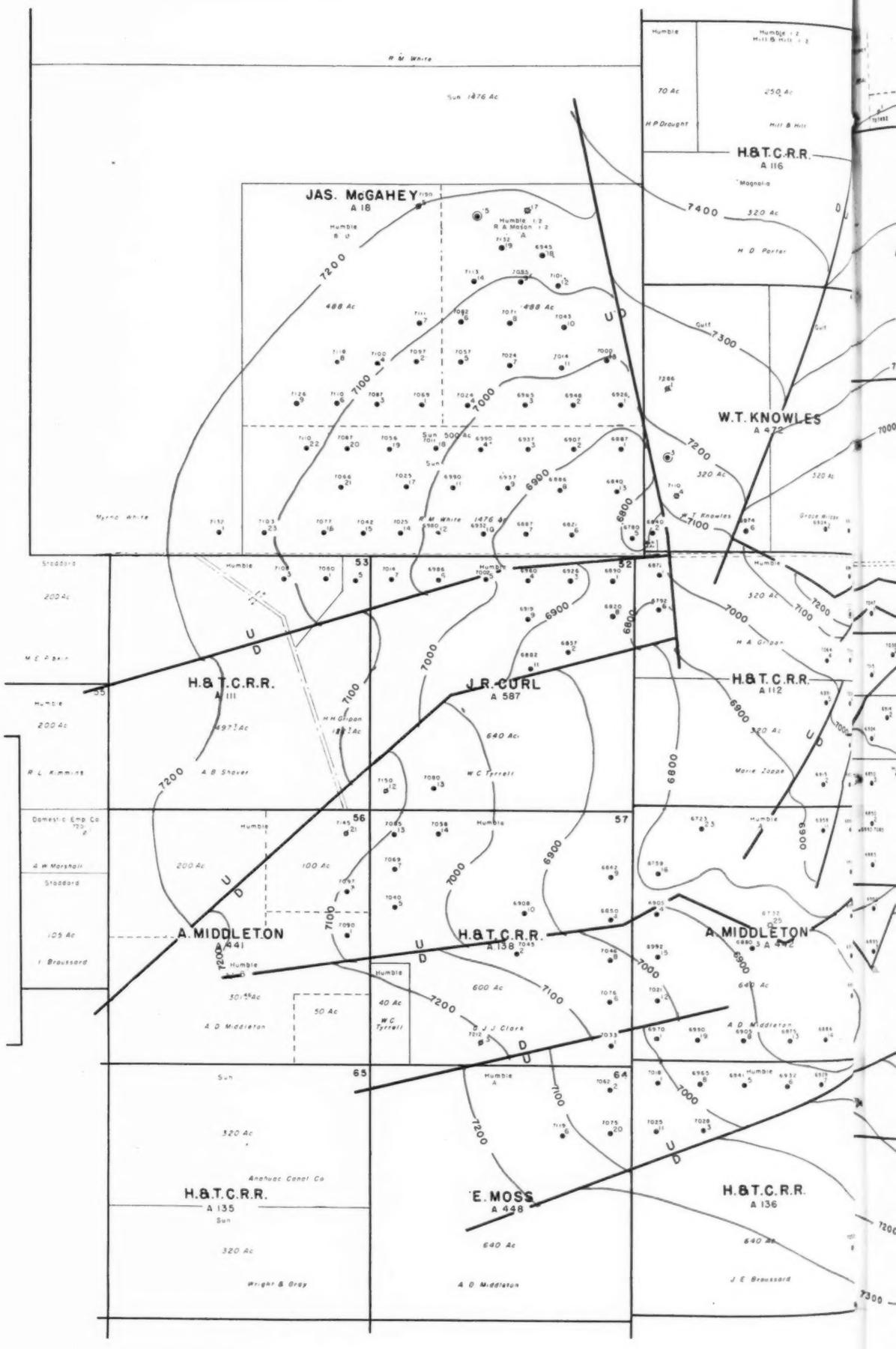
Cross section B-B, page 48, clearly shows this particular condition and the faulting and its effect on the sand. The fault that cuts across sections 56 and 52 and stops abruptly against the major fault running north and south across the James McGahey survey is the main fault which affected the

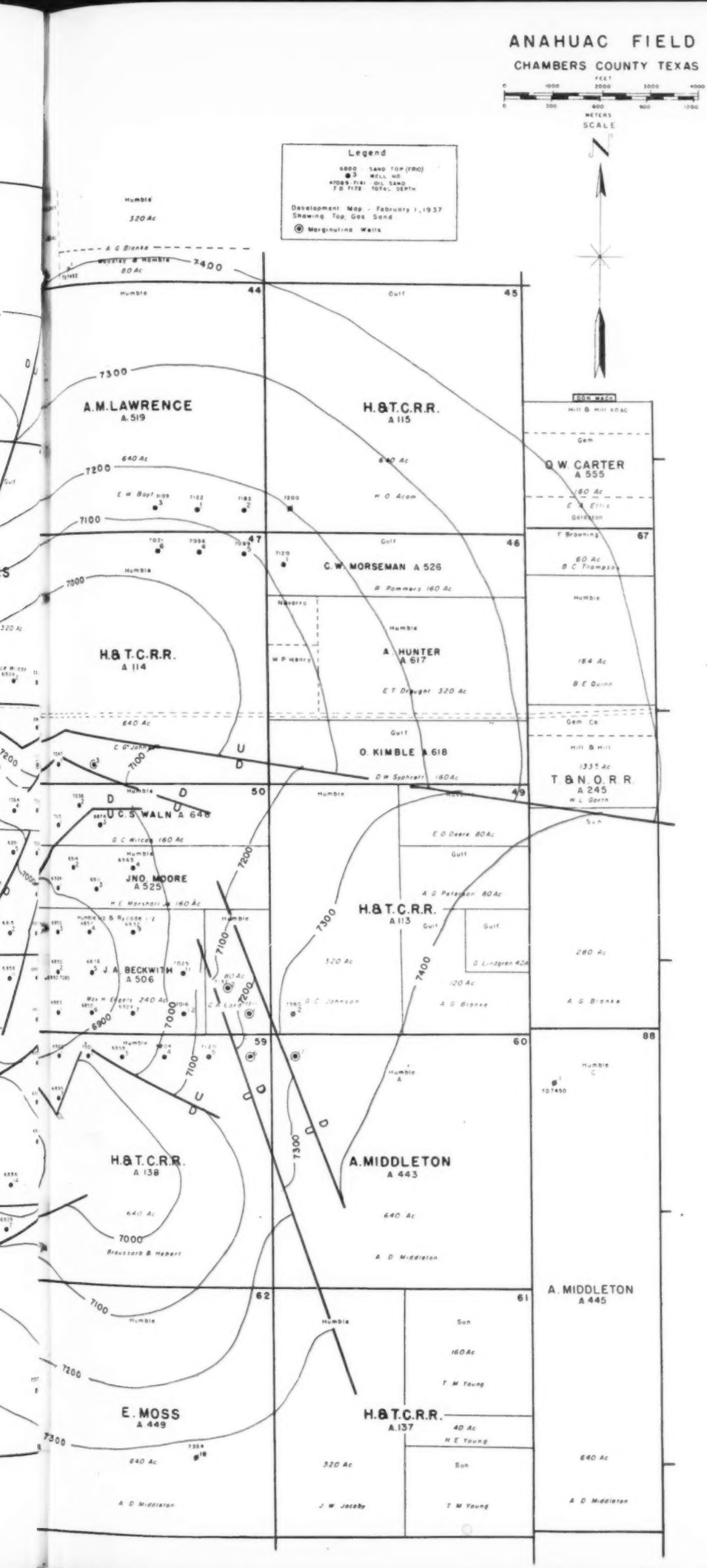
STRUCTURE MAP

Contoured on top of Frio Sand

By

M.T Holbouty and J Brian Eby





geophysical interpretation in the beginning. It will be noticed that the downthrow side of this fault is to the south and the upthrow side to the north. During the time of the geophysical shooting as a line was run north and south, the reflections caused by the downthrow side of this fault created a closure which gave such interpretations as to concede that the structure was dipping in such a manner as to be the end of the uplift. Not until the White No. 1 well, drilled by McCarthy, et al., was completed, which not only proved the northwest extension but also proved the existence of the fault which runs close to it as the well began drilling on the downthrow side and cut the fault in the *Marginulina* formation and penetrated the upthrow side.

The major fault which runs from section 56 through 57, through 58 and into section 59 is the major east-west fault. The component faults of this particular one are to the south. One of the faults forms a graben in the south half of section 57, the other component fault which runs across sections 64 and 63 forms a horst between it and the fault which runs to the north of section 44.

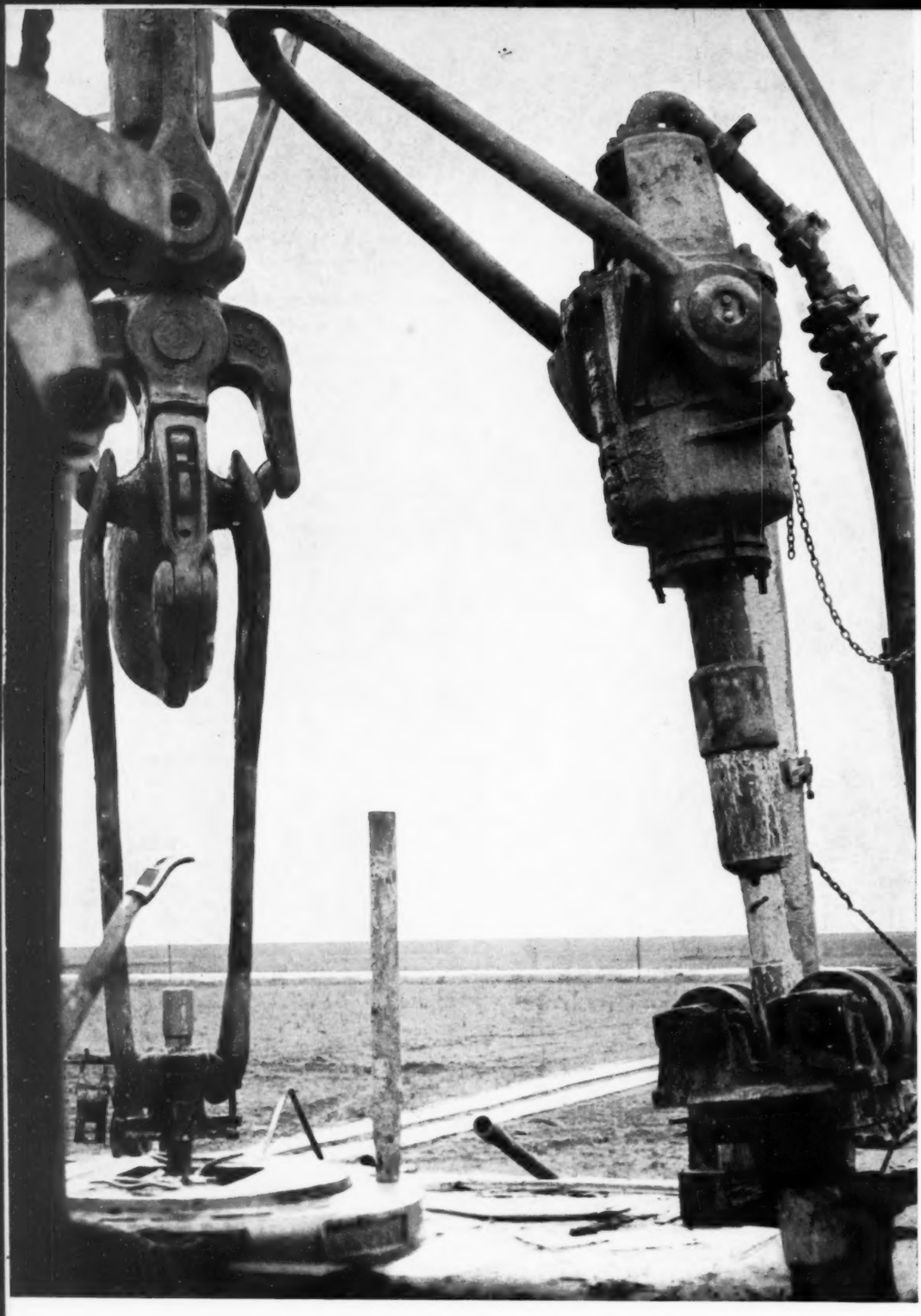
Cross section D-D, page 49, clearly illustrates the association of these faults to one another. To the east of the field two faults which run near the northeast corner of section 59 throws the Frio sand into the water level and causes the *Marginulina* sand, which lies above the Frio, to be faulted downwards into the oil section. This sand carries oil in sufficient quantities to produce. On this particular side of the field the *Marginulina* sand is productive only when the Frio is in the water level. However, in the northwest part of the field centering on the James McGahey survey the *Marginulina* sands overlap that of the Frio and both are productive. Those wells which have a ring around them are producing from the *Marginulina* sand.

Cross section C-C, page 49, and cross section A-A, page 48, shows the different alignment of the faults. It will be noticed that in cross section A-A the faults west and east of the graben are step faults. *Marginulina* production is obtained in this graben because the *Marginulina* sand has been faulted into the oil horizon. All of these cross sections show the extent and the thickness of the gas sand lying above the oil sand. In many cases it will be observed the gas sand has been faulted completely out.

The system of faulting that has been proved to exist at Anahuac is a very complicated one and with the exception of the faults of the Hastings field, in Brazoria County, are the most complicated in the entire Gulf Coast.

PRODUCTION METHODS

Production methods at Anahuac are similar to those used in other fields where major companies operate. Three major oil companies control all of the acreage and the drilling of this acreage is conducted in quick successive steps which not only speeds operation but is economical as well. Seven complete rigs are at present operating in Ana-



Heavy-duty swivel used in Anahuac drilling operations.

huac distributed between the companies. The Humble Oil and Refining Company has four rigs, Gulf Oil Company has two rigs, and the Sun Oil Company has one rig. Future locations are always staked out and the slush pits, derrick, pipe racks, surface pipe laid on pipe racks, and roads are built and constructed in such manner as to wait for the rig equipment to move in and begin operation. If a well is completed on one particular day, the rig is moved over to the next prepared location and is spudded-in by the next day. With the trucking and drag lines available the rig is moved and set up in less than 24 hours and the drill-pipe rotating and making hole by the end of the 24th hour after the first piece of equipment was moved from the completed well. Drilling conditions are almost ideal at Anahuac with no hard formation digging and the average time for completing a well into the tanks from the spudding date is 20 days. Considering the wells to be at depths of approximately 7100 ft., this time is unusually fast for the Gulf Coast. Approximately 800 ft. of hole is made per day, and counting cementing time for the surface and long strings, the well is completed in 20 days. Procedure in drilling is based upon a conservative basis in the following manner. As stated above, the derrick, etc., is all ready for the rig to be moved on the location which takes about 24 hours to rig-up the equipment in such manner as to begin actual drilling. Many minor features are not rigged-up in this initial operation as it does not become necessary until after surface casing is set. Approximately 1500 ft. of 9⅝ inch, 34.80 pound, Grade "C" casing is set for the surface string and cemented with 300 sacks of cement. During the time allowed for the cement to set, which is 48 hours, the rest of the equipment which was not rigged-up in the initial operation is completed and the rig is put in first-class shape to begin digging the lower hole. Operations are then started with an 8⅝ inch bit, and the hole is made with good 9.6 to 9.7 pound mud which is relatively low in sand content, and has a viscosity A.P.I. funnel measurement of 36 to 38 seconds. Blow-out drills are conducted on every crew and every precaution is maintained to prevent blow-outs during drilling of the well. The cuttings of the drilled hole are caught and paleontological determinations are made on them by the field paleontologist, who by his knowledge of other wells already completed, gives the coring depth. On a relatively high well and where gas sand is authorized, coring would begin at approximately 7007 ft. which is the oil and gas contact. If the well is running low, the well is cored from the corresponding depth difference in the height of the well. On the high wells where a full oil section is present, the coring is continued to about 7085 ft., and on low wells as much as five to 25 ft. of oil sand would be sufficient. The coring is done by the wire-line method, in which a core barrel assembly with a catching latch on top of the core barrel is dropped into the drill pipe while the pipe is in the hole, and after a few minutes the barrel fits snugly into a hole in the core-head-bit at the bottom of the hole. The barrel is pumped down the pipe, and after it is in place, the core is cut and the barrel is ready to be pulled. An overshot fishing tool, especially made for catching the latch on the core barrel, is dropped into the drill pipe with a ⅝ inch wire-line attached to it. This overshot drops over the latch on the core barrel and catches it and is pulled out by small engines attached to the wire-line reel. The barrel is dropped into the hole, core is cut, pulled out, and looked at in about an hour's time. Thus a complete coring job is usually through in eight hours. After the core record is determined the oil string is set which at the present time is 5½ inch O.D. 17 pound, Grade "C" casing.

The "present time" is emphasized because when the development of the field was in an early stage three strings of pipe were set: first, about 40 ft. of 16 inch conductor pipe

Anahuac Production By Individual Leases

Lease	Company	No. of Wells	Production in Barrels 1935	1936	Total
E. W. Boyt	Humble	1	.....	9,305	9,305
J. E. Broussard	Humble	7	51,312	170,210	221,522
Broussard & Hebert	Humble	7	11,340	131,428	142,768
Clark	Humble	11	69,499	267,094	336,593
H. A. Cripon	Humble	6	.....	90,754	90,754
M. H. Engles	Humble (Rycade)	9	20,989	184,091	205,080
C. A. Lord	Humble	2	.....	31,411	31,411
C. G. Johnson	Humble	3	.....	40,210	40,210
H. E. Marshall, Jr.	Humble	3	.....	56,923	56,923
Middleton Acct. No. 1	Humble	17	90,272	365,913	456,185
Middleton Acct. No. 2	Humble	3	32,615	62,885	95,500
Middleton Acct. No. 3	Humble	1	4,559	29,206	33,765
Middleton Acct. No. 4	Humble	1	.....	9,619	9,619
Middleton "B"	Humble	1	9,350	22,135	31,485
A. B. Shaver	Humble	2	.....	10,325	10,325
W. C. Tyrell	Humble	7	.....	158,368	158,368
Tyrell Trust	Humble	3		36,264	36,264
White	Humble	15	36,057	260,621	296,678
White	Humble	3	.....	21,782	21,782
G. C. Wilcox	Humble	3	.....	49,566	49,566
Marie Zeppe	Humble	5	2,461	92,708	95,169
Knowles	Gulf	2	.....	38,658	38,658
Myra White	Sun	1	.....	4,826	4,826
White	Sun	23	358,765	2,579,247	2,938,768
		136	687,219	4,723,549	5,410,768

was set, then about 2000 ft. of 10¾ inch O. D. pipe, then lastly a 7 inch O. D. oil string with 5½ inch screen, liner and packer. After the drilling became familiar, the two string arrangement proved profitable, that is, with about 1500 ft. of 9⅝ inch O. D. casing for the surface string, and 5½ inch O. D. casing for the oil string, with 3½ inch O. D. screen, liner, and packer set inside the oil string.

Wells are washed in with clear water and brought in under small chokes. The production is limited to flow 63 bbl. per day. All of the wells are flowing.

The Lone Star Canal Company's canal runs through the heart of the field and fresh water for the use in the boilers is obtained from this canal. Pipe lines are laid from this canal to the location. The cost of the water for each well is about five dollars per day or a total of $100.00.

Gas is furnished to the boilers from other wells already completed in the field. A central distributing system is maintained on each lease which furnishes the gas for the drilling of the other wells on the lease. A very large supply of gas is available at Anahuac because of the thick body of gas sand overlying the oil sand.

COST AND PROFIT

The total cost of drilling and completing a well at Anahuac into the tanks is $27,000.00. Up to February 1st, 1937, there have been a total of 155 wells completed, for an estimated cost of $4,185,000.00. The Humble Oil and Refining Company has completed 115 oil wells, one gas well and 10 failures; the Sun Company has completed 24 oil wells, no gas wells, and no failures, and the Gulf Oil Corporation has completed 3 oil wells, one gas well, and one failure. Each well has been dug on a 20 acre ruling which nets a total of 142 oil wells, 2 gas wells, and 11 failures, or a grand total of 155 completed wells. The 142 productive oil wells, on a 20 acre basis, prove up 2840 acres, and on a basis of 30,000 bbl. of recoverable oil per acre, the present wells will ultimately produce 85,200,000 barrels of oil. These figures must not be confused with the estimate of ultimate reserves for the field which are given later in this article. Including gauge copies, etc., to the cost of the drilling of these producing wells which together will possibly total $4,500,000.00 the profits from the digging of the 155 wells, from which 142 are producing, is $80,700,000.00.

PIPELINES

There are two pipelines serving the oil outlet at Anahuac. The Humble Oil & Refining Company has a six-inch line which leads to Moss Bluff and thence to the Humble Refinery at Baytown. The Sun Company runs oil from the lease tanks to the Humble Pipe Line Company's storage tanks where it is gauged and then pumped into the Humble Pipe Line to Moss Bluff, 18 miles to the northwest of Anahuac. At Moss Bluff, the Sun Oil Company's oil is then pumped into its own pipeline which pumps the oil to the Company's storage tanks at the Smith Bluff's terminal on the Neches river, near Beaumont.

The Gulf Pipe Line Company buys the Gulf Oil Corporation's oil and runs it through a four-inch pipeline to Hankamaer, 11 miles north of the Anahuac field, and thence it is pumped to the Gulf Refinery at Port Arthur.

ESTIMATED RESERVES

A reasonable and conservative estimate of ultimate recoverable oil at Anahuac, in the writers' opinion, is 350,000,000 bbl. This estimate is based on a study of the development map of Anahuac as of December 31, 1936, see Plate 1.

In computing this estimate a recoverable factor of 600 bbl. per acre foot was used. The footage of oil sand is based on the thickness of the oil-bearing portion of the sand, being that portion of the sand above the general water level of 7140 ft. depth, and the oil-gas contact in the sand. The logs of about 130 wells were considered.

On the basis of well log data and present development it is considered that there are approximately 5000 acres of an average thickness of 100 ft., 1500 acres of an average thickness of 50 ft., and 1000 acres of an average thickness of 10 ft. This estimate of average and thickness of sands predicts a yield of 351,000,000 bbl. of which 3,000,000 bbl., or about 1/117th, has already been produced, see Plate 7. With this enormous quantity of oil in sight, the Anahuac field definitely becomes one of the major oil fields of the Texas-Louisiana Gulf Coast.

Unloading heavy draw-works from heavy-duty truck. Note the board roads and also the quantity of mud, which was quite prevalent in the Anahuac District before shell roads were completed.

LONG RANGE PLANNING OF TANKER REPLACEMENTS

Both Owners and Shipbuilders Will Benefit by a Program of Steady Building Arranged to Keep Fleets Up to Oil Company Needs

(The following article is written by a man whose long experience and close study of tanker construction and operation entitles his views to careful consideration by those concerned with tanker fleet maintenance, especially in view of the rapid increase at the present time in American shipyard activities. —Editor).

IT IS timely to consider, in view of past experiences, the effect that further tanker construction will have on American shipbuilding as well as on the oil industry. Men engaged in the oil business need make only a cursory tour of inspection through some of the older refineries in order to be impressed with the large amount of idle equipment which has been made obsolete through engineering advancements. In spite of the fact that the petroleum industry has been outstanding in its acceptance of new processing equipment on the basis of economies effected, an inquiry into existing water transportation facilities shows the lack of any general program for making similar economies. Increased demand for domestic oil products in America, and the general trend toward Gulf Coast refining, has stimulated purchase of new tankships for coastal transportation. Present indications point to increased tanker replacements as well as additional tonnage requirements.

American shipbuilders, confronted with the knowledge that tankships represent more than one-quarter of all of the American merchant tonnage, and that tankers are the only wholly privately-purchased merchant ships likely to be contracted for, have not been slow in advancing tanker design. Long periods of inactivity have provided time in which to develop many features. Recent progress in tanker design has furnished striking advances in the three requisites of any merchant ship: operating efficiency, maintenance economy, and safety and comfort. Many of the detailed advancements incorporated in the modern tanker are controversial from the standpoint of class of service in which the vessel is placed. As a unit, however, their many features combine to make them outstanding examples of American engineering.

Introduction of welding, and new arrangements of tanks, bulkheads, and framing, have effected savings of weight in hull construction. Developments in design of propellers, rudders and hull forms have led to higher speeds with less power consumption. Improvements in high-pressure and high-temperature geared steam turbines and water tube boilers have similarly effected space and weight economies, as well as operating efficiencies, while there has been marked progress in compacting machinery without loss of accessibility. Due to these features, recent American-built tankships claim the distinction of being the largest bulk oil carriers for their size. Elimination of combustible materials, fire-proofing of living quarters, and insulation of these quarters from the decks and shell plating, have contributed to the added safety and comfort of the ship's personnel.

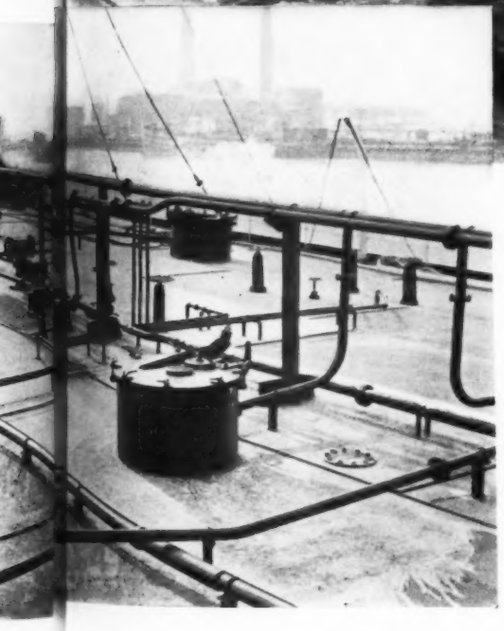
Considering the high labor costs and absence of continuous tanker work, American-built vessels are relatively cheap; this, in a large part, is due to the fostering of better designs and simplicity in construction. European shipbuilders are not subject to such extreme buying cycles as have been the lot of American yards, and, as in all heavy industry, continuity of work is a prime factor in the reduction of costs.

Periods of tanker building have followed fairly closely periods of world-wide construction of general merchant vessels. In the past thirty years world merchant construction averaged some 2,500,000 gross tons annually, of which roughly 1,100,000 tons per year were built in Great Britain and Ireland. During the four shipbuilding peaks experienced during this time, Great Britain reached a maximum of 185 percent of her normal rate during the post war period of 1919 to 1920, while the rest of the world soared to 388 percent—mainly due to American excesses. Considering that the normal life of a tanker is generally accepted to be about twenty years, maximum, it is the vessels built during this period which are about to be replaced. American oil companies now have the opportunity of laying out a definite schedule of ship replacement extending over an advanced period of years. Such a program, beneficial because of the constant introduction of new and more economical units, would also witness the continual promotion of tanker development by affording shipbuilders continuity of work on this class of ship.

Tanker owners have recently enjoyed unique advantages due to the keen competition existing between shipbuilders for their business. Prices were cut to the bone and builders were able to give most, if not all, of the attention to orders received from oil companies. Since then the situation has undergone a number of changes and a problem facing tanker owners today is the necessity for long-range planning of tanker construction. Statistics show that the American fleet, which is over 2,400,000 gross tanker tons, has reached a state of obsolescence such as to require heavy constructional programs for several years. An estimate puts this in excess of 300,000 tons gross per annum during each of the years from 1937 through 1941, representing about 25 tankers per year. Oil companies have placed orders in the United States for a total of 33 tankers over a period of two years, or about 105,000 gross tons per year—approximately one-third of that contemplated above, which, exclusive of other mercantile business, would probably require the output of the principal American shipyards.

The tendency of the hour towards increased naval building also influences the situation and shipbuilders are no longer dependent upon the petroleum industry for business. Recent commencement of American shipping subsidies will soon bring about construction of other classes of merchant ships. Add to this the increased naval shipbuilding which is now under way and that contemplated, along with the expected tanker requirements, and it may be seen that

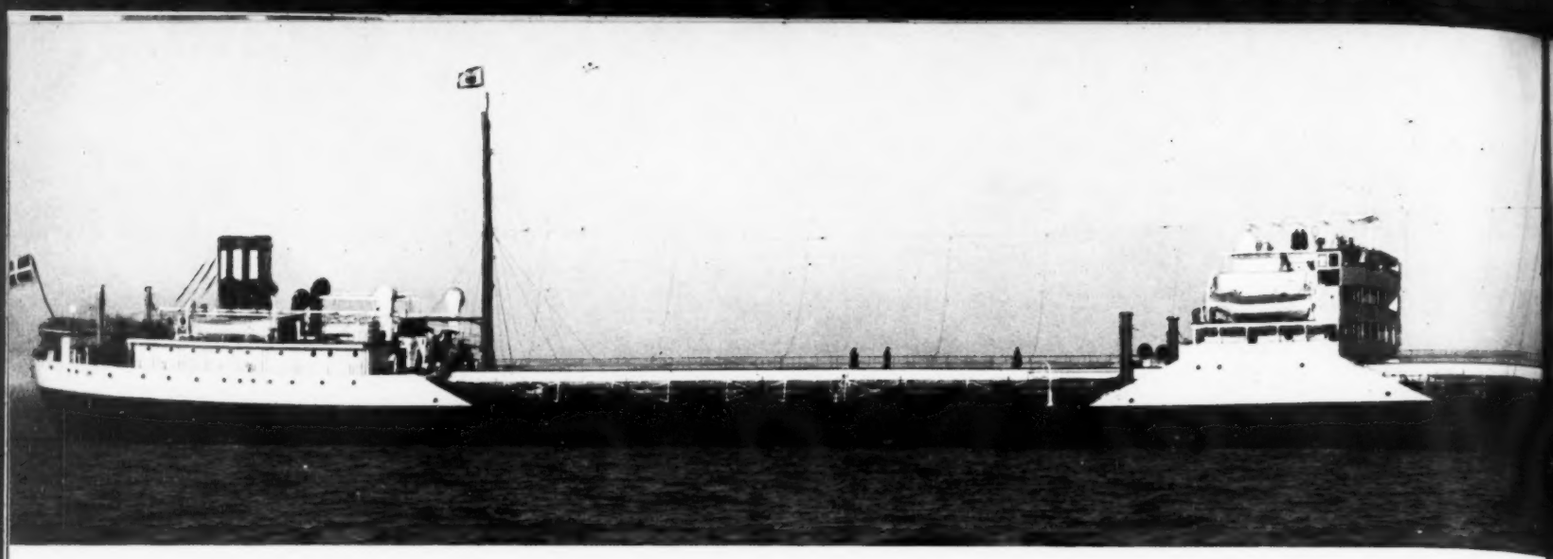
Tanker replacements necessary to maintain the American fleet at a normal level are more than twice the present program and would tax the nation's largest yards.



American shipbuilding facilities will be taxed to the limit, in view of the fact that the present day program is considered large. In the scramble for new bottoms by both naval and mercantile interests it is not unlikely that considerable difficulty may be encountered by oil companies who wish to replace and/or augment their fleets.

All these inconveniences might be obviated by such a farsighted scheme as has been proposed for steady construction over a number of years. Shipbuilders would undoubtedly welcome such an arrangement inasmuch as it would eliminate their troubles of alternate slack periods with little or no tanker contracts being placed and the times when their yards are so busy that they find difficulty in handling all available orders, with resultant increase in prices and possible diversion of certain of these contracts to builders abroad. Advantages of such a scheme would not be one-sided but would be apparent on the part of both builder and owner, assuring one of constant activity and steady income, while the other would obtain its new vessels at more reasonable prices, a reduced capital outlay would be involved at any one time, while under such circumstances it would be possible to take advantage of each individual technical development as it came along.

There is marked evidence to show that a few of America's major oil companies are contemplating such a program. Of two-dozen tide-water fleet owners, however, only seven have contracted for new tonnage and five have shown signs of a possible comprehensive long-range schedule. In view of the fact that most of the successful and experienced European merchant ship and tanker owners have replacement building continually under way, and as the time is now propitious, adoption of such a policy is important; reduction of transportation expenses is involved—a salient factor in the cost of America's domestic oil products.



French motor tanker Henry-Desprez, which took the first cargo of Iraq oil from Tripoli terminal.

PROGRESS AND PROBLEMS OF TANKER DEVELOPMENT

Growth in Demand for Petroleum Products Has Led to Rapid Expansion of Fleet which Now Exceeds 9,000,000 Tons—Specialized Types Required to Fit Particular Services

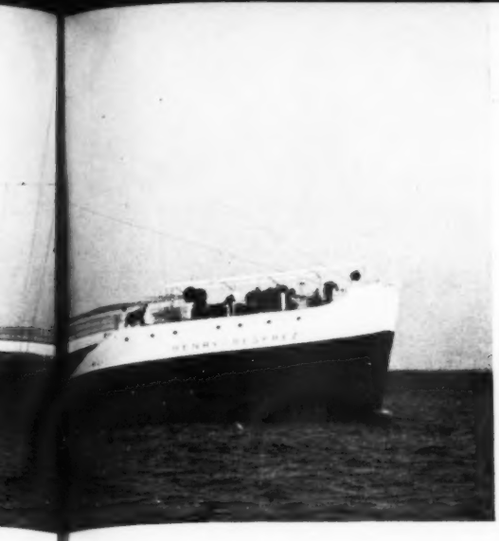
THE OIL TANKER business, in just a little more than 20 years, has sprung from comparative insignificance into considerable importance. The greater development, of course, has taken place since the war years. Before then it was usual to think of oil tankers as part of a comparatively small fleet. Up to about 1914 relatively little use was made of oil by the mercantile marine although it was becoming universal in the navies and, in its various forms, was beginning to assume increasing importance for domestic and industrial purposes. But the tonnage of motor ships at 1914 was only 234,287 tons, including auxiliary sailing vessels. The tonnage of steamers fitted to burn oil fuel was 310,200 tons and in the accompanying tables the figures for the intervening years show the extraordinary changes which have taken place.

By 1929 there were approaching 7,000,000 tons of motor ships and more than 19,000,000 tons of oil fuel burners. The latest figures show that there are more than 9,000,000 tons of tankers and 12,250,000 tons of motor ships. In 1914 some 89 percent of the mercantile marine was burning coal; only 2.65 percent was burning oil for steam raising, and 0.45 percent of the tonnage was represented by motor ships. The latest figures show that the coal burning fleet has shrunk to 49 percent of the world's tonnage; the oil burners are now more than 30 percent and the motor ships nearly 19 percent.

These developments naturally have had a considerable effect on the evolution and growth of the oil tanker fleet, quite apart from the very much greater use of oil in its various forms on shore and the enormous consumption of the lighter grade oils for the ever-growing numbers of automobiles.

Expansion of the tanker fleets has not progressed at regular rates but has fluctuated widely in accordance with various economic forces which have reacted on the two great branches of the sea-borne traffic, the liner companies and the tramps. One might have thought that, with its great international ramifications and with the fact that the oil industry as a whole is dealing virtually with one commodity there would have been by this time little use for the tramp tanker. Such, however, is not yet the case and he would be a bold prophet who ventured to

Refueling tanker for seaplane service—one of the first designs adopted.



predict that we have seen the last of large scale construction of virtually uncontrolled tonnage such as led to the formation of the International Tanker Pool, which is now operating with conspicuous success.

Both the general freight market and the oil tanker market are now undergoing processes of international control as a result of the lessons of the past three years of acute depression, and it may yet be that, with the return to prosperity which now seems evident, less disciplined members of the tanker tramp community will have learnt their lesson and fallen more in line with the broader outlooks of the bigger organisations. If so, the abandonment of what at times really amounted to commercial piracy, will introduce a greater measure of stability and avoid those violent fluctuations of shipbuilding construction which, in all branches of shipping, invariably have precipitated a crisis.

With the broadening of demand for petroleum products, as a consequence of improved industrial and commercial conditions in many countries, there is today and should continue, in the near future, a fairly steady demand for all really employable oil tanker tonnage afloat. It is doubtful, however, whether, so far as bulk is concerned, the oil industry can look, just at present, for increasing traffic from the mercantile marine. Table I indicates that there is a decided decrease in tonnage of shipping burning oil for steam raising, and with development of the motor ship one may almost believe that the figure of 20,135,000 tons of oil fuel burning vessels reached about three years ago may prove a record. Whether this is so or not depends on the ingenuity of the steam engineer in evolving new types which will combat the increasing competition and general convenience of the motor ship which appears on the oceans in ever-increasing numbers. In such an eventuality as a further decline in use of oil burning steamers one may expect important changes in the types and distribution of that important section of the oil tanker business which is concerned primarily with bunkering, especially in view of the small fuel consumption of Diesel engines and amazing cruising radius of the motor ship. In time this must have an effect on geographical distribution of bunkering stations.

Quite apart from the varied requirements for industrial and domestic use, one may expect the tanker fleet, as a whole, to consist of more miscellaneous units than at present. It is likely that there may be bigger—and there certainly will be faster—oil tankers than are in service today. But, after all, the increase in size is not so remarkable when we realise the stir that was created in 1912 by the Eagle Oil Transport Co. Ltd., as it was then known, when it took the advanced step of ordering ten 15,000-ton oil tankers of the SAN FRATERNO class, so called after the first ship of the series, which went on trials in April, 1913. These ships had a contract speed of 11¼ knots and were propelled by quadruple-expansion steam engines burning oil fuel. Larger and faster ships have come along since then but the general trend of these large vessels appears to be in the region of 18,000 deadweight tons with a speed of 12 or 13 knots. Naval requirements, of course, have introduced faster ships, notable examples being some of the tankers for Japan.

With the development of the British Navy one may of course look for similar influences among British tankers. British Admiralty requirements, however, may be momentarily judged from the recent purchase from Anglo-Iranian interests of six 12,500 ton tankers under construction. They are Diesel engined and will replace existing steam driven tankers. Their speed is to be 12 knots.

Below the bigger ships, however, there must continue to be an indefinite range of supplementary vessels including intermediate sized feeders for the short seas trades, the coastal tankers—which are now coming along in increasing numbers especially for use around the British Isles for reducing road haulage where there are wide estuaries—and for bunkering on longer rivers such as the Thames and Humber. Indeed, there seems no end to the variety of the smaller type of tanker since only within recent months Imperial Airways, having decided to use flying boats for the development of Empire air routes, has issued inquiries for motor launches and auxiliaries to act as tenders, these including steel heavy duty launches which are being built to the account of the oil companies to act as refueling tenders. Likewise there are the travelling marine "service stations" for pleasure craft. This development introduces a new fleet of what one might term mosquito craft which are, for all practical purposes, small tankers driven by high speed Diesel engines.

TABLE I

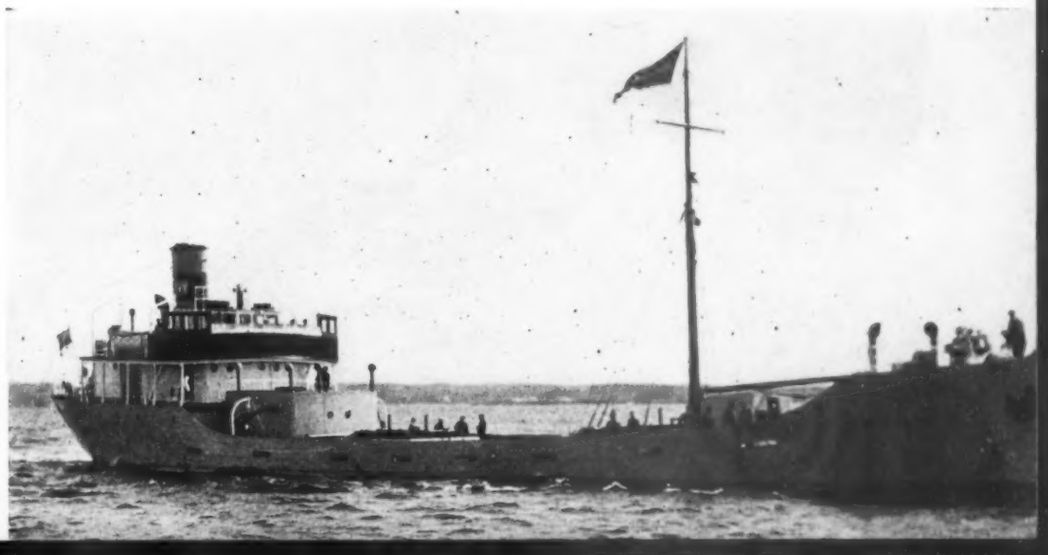
Lloyd's Register Year	Motorships Tons	Oil fired steamers Tons
1936	12,290,600	19,766,700
1935	11,304,690	19,885,070
1934	10,604,526	19,857,700
1933	10,200,392	20,053,273
1932	10,038,377	20,135,006
1926	3,493,284	18,243,540
1921	1,248,800	12,796,630
1919	752,600	5,336,678
1914	234,287	1,310,210

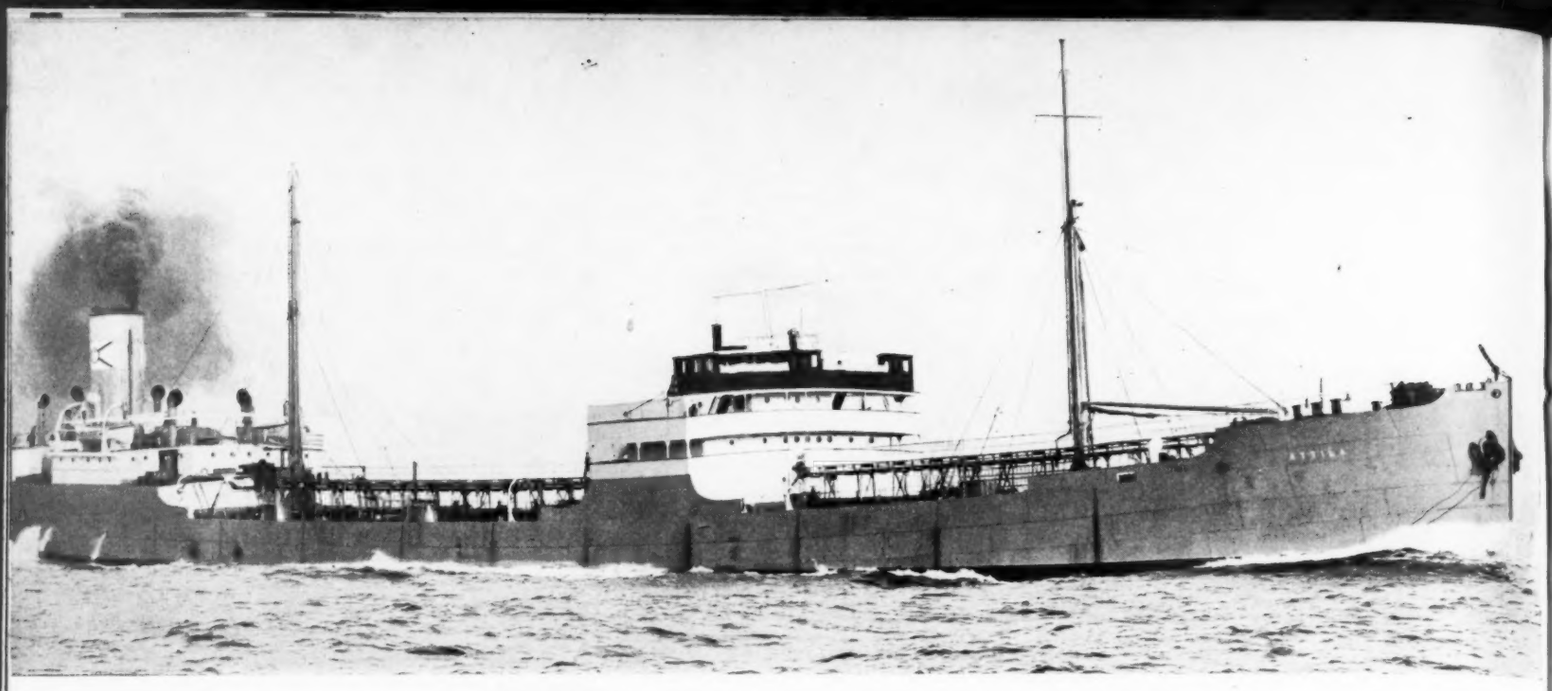
In the interval which has elapsed since the war the owners of oil tankers, and particularly the experts who design and operate the fleets, have acquired considerable specialised knowledge of their requirements, and have more than kept pace with current naval architectural research. They have profited considerably as a result of their enterprise. Fullest use has been made of experimental tanks and of the increasing knowledge of the best types of propellers to adopt on various types of hull forms. In addition, to this, of course, the tanker owner has had to surmount his own peculiar troubles, such as corrosion, all of which have resulted in the peculiar efficiency of the tanker of today.

There is no longer any need to speculate as to the relative merits of twin screws or single screws. They can be judged almost to a nicety before the ship is ordered and in making the selection it often resolves itself into the necessities of local requirements as to whether manoeuvreability suggests the greater convenience of twin screws. Problems in this respect are not very different from naval architectural problems as a whole and an examination of current practice shows increasing preference for the greater efficiency of a single screw where this can be achieved by use of a suitable prime mover. This is not so difficult with the higher powers per shaft nowadays obtained.

The naval architect has yet to solve the problem which, no doubt, the whole petroleum world would acclaim with open arms. This is the introduction of a tanker designed to carry two-way cargoes. Something along these lines is now being attempted in an experimental way in Japan, where certain tankers have been constructed for the carriage of silks and similar high-grade goods. A few other dual-purpose tankers have been

Soya IV, a coastal tanker for Baltic Sea service.





A tanker of the type built for Norwegian ownership six or seven years ago.

built, but they have all been limited to liner routes.

Those who have been responsible for creation and maintenance of the huge oil tanker fleet of today, whether liner or tramp organisation, may well pause and wonder whether they have been the spoilt children of adversity which has enabled them, in the years succeeding the war, to take advantage of acute shipbuilding depressions. It is possible that they may not be able to ring the international changes much longer in the way they have done in recent years. They have been able to order from British shipyards when the builders were on their knees. They were able to exploit Scandinavian interests at the psychological moment. And, latterly, the urgency of releasing frozen credits from Germany has filled some of the German yards with very welcome foreign business. Look at this list of work in hand at the Deutsche Werft, Hamburg, at the beginning of this year:—

Of these 33 ships only seven are for German ownership—the rest are foreign. Twenty three of the ships are tankers and there can be no precedent in modern shipbuilding history of such an extraordinary sequence of business for which the oil industry is primarily responsible. Of 80 oil tankers of 652,200 tons building throughout the world at the beginning of this year, 11 of 125,000 tons were returned by Lloyd's Register as

TABLE II

At Jan. 1	Total Shipbuilding Ton gross	Oil Tankers Ton gross	Per Cent Tankers
1937.....	2,251,200	652,200	25
1936.....	1,543,000	438,600	28
1935.....	1,251,700	338,000	27
1934.....	757,300	117,600	16
1933.....	765,700	194,500	25
1932.....	1,403,800	351,300	25
1931.....	2,326,100	907,300	39
1930.....	3,110,900	627,800	20
1929.....	2,618,000	362,000	14
1928.....	3,118,700	744,700	24
1927.....	1,933,000	371,500	19
1926.....	2,069,500	308,500	15
1925.....	2,470,400	309,300	12
1924.....	2,444,300	175,200	7

building in Germany. This suggests that a large number of tankers in the above list have yet to be put in hand. The figure, however, is exceeded by the tankers actually under construction in Great Britain and Ireland, there being 23 of 179,800 tons.

The latest statistics show that apparently 25 percent of the total shipbuilding production consists of oil tankers, a figure which considerably exaggerates the actual proportion today so far, at least, as British shipyards are concerned, since Lloyd's Register statistics do not take cognisance of the large amount of naval work in hand.

During the depression prices often favored the tanker owner very much. At the moment British shipbuilding prices are at least 30 to 40 percent higher than they were two years ago, and with the increased cost of steel which is imminent and the higher wages which have been promised, costs are bound to go higher still.

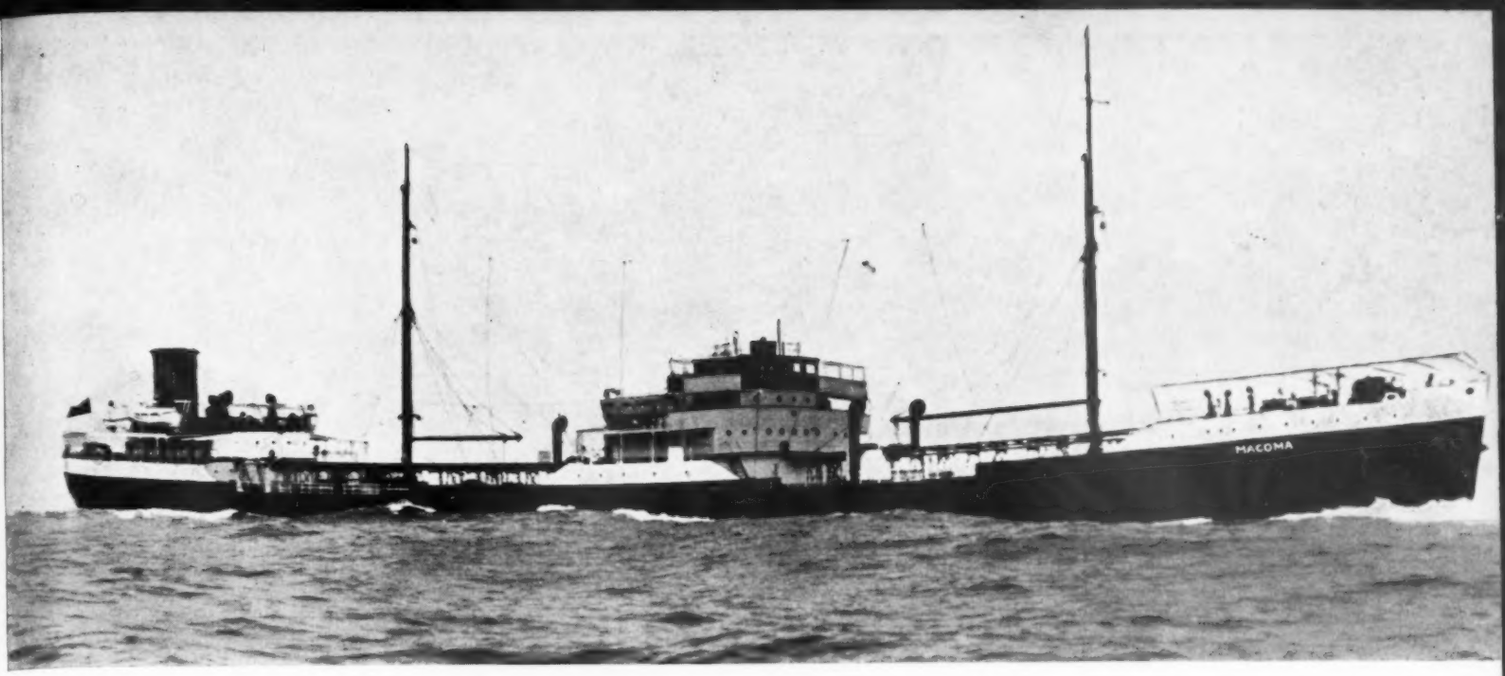
Both in Germany and Britain the armaments race is tending to slow down the constructional pace of all mercantile work. Those concerns who are seeking outlets of other yards, such as Holland, are likely to find their efforts frustrated by inability of the Dutch to secure steel from either Germany or Great Britain, which are their primary sources of supply.

These very important changes have occurred only during the past year or so. They might almost be said to be in the primary stages of evolution. They cannot, however, be ignored by the tanker community which has been able to draw so freely upon all Continental shipbuilding resources—indeed, to a large extent may be said almost to have created them. An examination of Table IV will show the extraordinary changes which have taken place in this respect and is a reminder how nations which only a few years ago were hardly regarded as of any importance in the competitive field have been able to tackle an admittedly difficult type of construction formerly regarded as highly specialised work capable of being undertaken only by very experienced workers. They have also been able to cater to the varied requirements of the oil industry which, as has been said, now requires a very wide range of tonnage of all shapes and sizes.

At the extreme end of the big tankers there is the EMILE-MIGUET which will be launched in an almost completed stage by the middle of April from the shipyard of the Ateliers and Chantiers de France at Dunkerque. She is the largest French tanker, displacing something like 30,000 tons and having a carrying capacity of more than 21,000 tons. In this case twin screws will be adopted, propelling machinery consisting of single acting Burmeister & Wain Diesel engines built at Penhoet.

Yard Number	Type and Tonnage		Engines
172.....	Tanker	10,000 tons	M.A.N. Diesel
174.....	Passenger	15,000 tons	M.A.N. Diesel
175.....	Tanker	10,000 tons	M.A.N. Diesel
181.....	Tanker	10,000 tons	M.A.N. Diesel
183.....	Tanker	10,500 tons	M.A.N. Diesel
184.....	Tanker	10,500 tons	M.A.N. Diesel
188.....	Cargo	5,300 tons	M.A.N. Diesel
189.....	Cargo	5,300 tons	M.A.N. Diesel
190.....	Cargo	5,300 tons	M.A.N. Diesel
191.....	Cargo	5,300 tons	M.A.N. Diesel
192.....	Tanker	10,000 tons	M.A.N. Diesel
193.....	Tanker	10,000 tons	M.A.N. Diesel
194.....	Tanker	10,000 tons	M.A.N. Diesel
195.....	Tanker	10,000 tons	M.A.N. Diesel
196.....	Cargo	4,500 tons	M.A.N. Diesel
197.....	Whaler	15,000 tons	Steam
198.....	Tanker	10,500 tons	M.A.N. Diesel
199.....	Tanker	10,500 tons	M.A.N. Diesel
200.....	Tanker	10,500 tons	M.A.N. Diesel
201.....	Tanker	10,500 tons	M.A.N. Diesel
202.....	Tanker	10,000 tons	M.A.N. Diesel
203.....	Tanker	10,000 tons	M.A.N. Diesel
204.....	Tanker	10,000 tons	M.A.N. Diesel
205.....	Tanker	10,500 tons	M.A.N. Diesel
206.....	Fruiter	3,000 tons	M.A.N. Diesel
207.....	Tanker	10,000 tons	M.A.N. Diesel
208.....	Tanker	10,000 tons	M.A.N.Diesel
209.....	Tanker	10,000 tons	M.A.N. Diesel
210.....	Tanker	10,000 tons	M.A.N. Diesel
211.....	Tanker	1,000 tons	Krupp Diesel
212.....	Tanker	1,000 tons	Krupp Diesel
213.....	Cargo	3,500 tons	A.E.G. Steam
214.....	Cargo	3,500 tons	A.E.G. Steam

Further evidence of the international character of tanker business is shown in the remarkable range of Arcform tankers which



Royal Dutch-Shell twin screw motor tanker of current design.

Sir Joseph Isherwood has in hand for various tanker interests, but mainly American, the work being distributed among shipyards in the United States, Great Britain, Holland, Denmark and Spain. These range in size up to 15,000 tons deadweight although 12,500 tons is a general size.

Designers, moreover, have been called upon to cater to varied requirements as in the case of the COMANCHEE built last year by John Brown & Co., Clydebank, for the Anglo-American Oil Co. Ltd. With a carrying capacity of 10,300 tons and a speed of 13 knots, she was designed to transport in bulk several grades of lubricating oil including the Essolube and Essomarine series. Speed was an essential requirement and handiness another desideratum inasmuch as she had to proceed as near the Midlands of England as possible, and so would have frequently to discharge her cargoes at Manchester. Consequently the dimensions were restricted by necessities of ship canal locks. There is a special system of ballast tanks which lessens the need for carrying water ballast in the cargo tanks, a practice which it is now realised has many practical disadvantages.

By this special arrangement about 3,000 tons of water ballast can be carried in the ballast tanks and in the double bottom. Propulsion is by means of a single screw driven by a Brown-Doxford Diesel engine, steam for the heating coils of the tanks and for other purposes being obtained from a Clarkson thimble-tube waste heat boiler and one Scotch boiler, the latter for supplying steam when required to engine room auxiliaries and to take the heavier duty of supplying steam to the large cargo pumps forward. This is a modern example of a tanker designed to carry at one and the same time a number of different grades of oil, there being of late other examples of owners desiring such special features.

TABLE III

	Total Shipping * Tons gross	Tankers Tons gross	Per Cent Tankers
1936	64,005,000	9,195,400	14
1935	63,727,000	8,896,500	14
1934	64,358,000	8,668,500	14
1933	66,627,000	8,757,000	13
1932	68,368,000	8,911,000	13
1931	68,723,000	8,650,000	13
1930	68,024,000	7,628,000	11
1929	66,407,000	7,071,000	11
1928	65,159,000	6,620,000	10
1921	58,846,000	4,419,000	8
1919	47,897,000	2,929,000	6
1914	45,404,000	1,479,000	3

* Excluding sail.

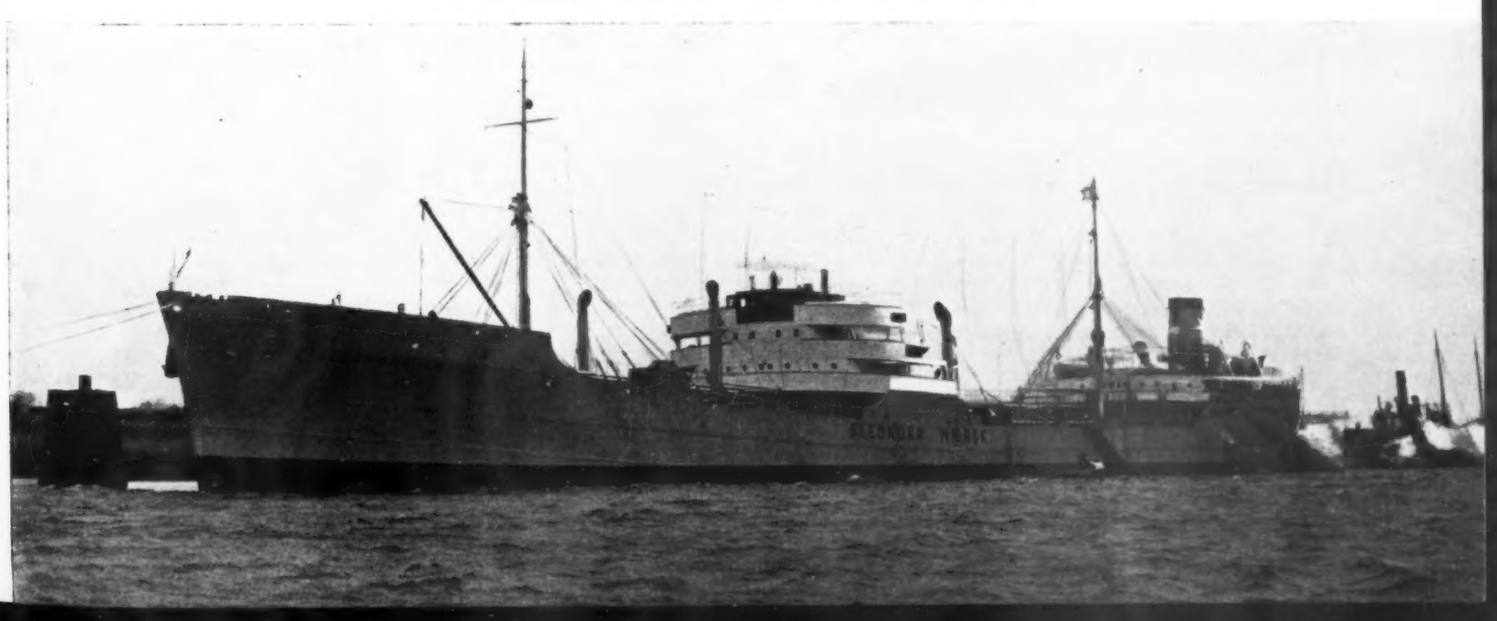
Reference has already been made to the experiment by Japan with two-way cargo tankships. This apparently arose out of the desire of Japanese interests to have tankers of sea speeds up to 18 knots. With this end in view the TATEKAWA MARU was built with a trial speed of no less than 22 knots and was designed for Pacific service, carrying silk from Japan to California and returning with crude oil for the Japanese Navy.

These examples show the wide variety of constructional problems the tanker community has set the shipbuilders of the world. The tanker is, obviously, of growing importance in maritime economics and its development is the more interesting because it has been concentrated over so few years.

TABLE IV

Building at Dec. 31	1936 Tons	1935 Tons	1934 Tons	1933 Tons
Gt. Britain & Ireland	179,790	114,040	94,000	31,026
Danzig	15,000	10,000	.....	.....
Denmark	46,800	25,000	52,900	8,070
Germany	124,980	101,700	57,450	.....
Holland	54,620	47,835	40,270	.....
Italy	22,000	6,400	8,200	.....
Japan	29,180	29,665	10,000	19,200
Spain	20,220	3,970	.....	18,212
Sweden	61,765	52,264	34,700	41,100
U. S. A.	79,840	28,200	18,600	.....

Eleonora Maersk is representative of modern European design.



MAINTAINING

World Tanker

Fleet

By A. C. Hardy

AT THE end of 1936 there were 80 tankers under construction in the world's shipyards, having a total gross tonnage of 652,202, of which 63, of 511,732 gross tons, were motor vessels and only 17, of 140,470 gross tons, steamers. Added to the 9,316,266 gross tons of bulk-oil carriers listed in the current Lloyd's Register these should bring the available tonnage to about 9,950,000 gross, a large increase from 5,664,786 gross tons ten years ago and a mere 1,478,988 tons at the beginning of the World War.

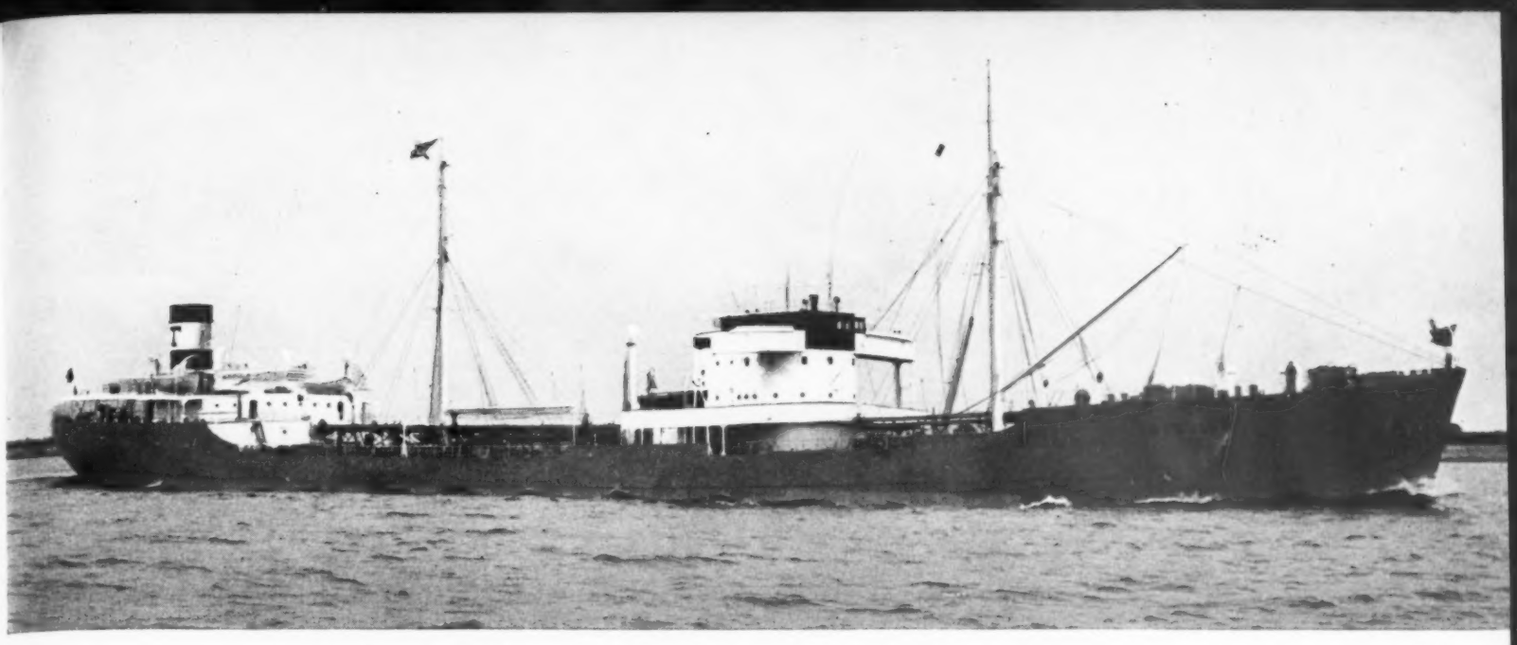
Increase in tanker tonnage in the past few years has been extremely rapid. Even in the slump period there was little decrease of total tonnage registered, the figures in 1932–3 being 8,911,258 tons, which dropped only to 8,776,009 tons in 1934–5. It would appear that over half-a-million gross tons will be added to the tanker total in the 1937–8 register book.

As far as the current situation is concerned the two tables specially compiled by WORLD PETROLEUM for this issue give an idea of the ships now under construction or on order throughout the world. Lloyd's returns provide an interesting analysis of the groups of vessels listed in these tables up to December 31, 1936, and the relative position has not undergone material change since that date. Great Britain is building 23 tankers with a total of 179,790 gross tons, and only two of 9,800 tons are steamers. Next on the list is Germany with 11 ships aggregating 124,980 tons, three of these being steamers of 43,200 tons. Tanker construction in Germany is of considerable importance at the present time, and two yards alone are constructing seven large tankers for one company, Crusader Petroleum Industries Ltd. The United Africa Company Ltd. is still well to the fore while Standard-Vacuum Oil Company, Standard Oil Company of N. J., and Standard Oil Company of California are also patronizing Germany in addition to United States yards. As has been the case for some years, Anglo-Saxon Petroleum Company Ltd. is among the largest individual builders, and here also German yards are used, although Great Britain can number among her group of tankships under construction several vessels for these owners and their subsidiaries. British Tanker Company Ltd. have 14 units building, three of which have been purchased by the British Admiralty for naval supply ships. Great Britain and Germany, then, are outstanding among builders of the world's tankships. If, as rumored, building in Germany for foreign account is to be controlled in the future, this situation may alter and the international advantages which oil companies received for building in that country disappear.

Denmark and Sweden are not so concerned with tanker building as has been the case in the past, the former showing only five vessels of 46,800 tons gross and the latter seven of 61,766 tons gross. These are mostly for Scandinavian ownership and while in some cases of standard type all show improvement both as to machinery, hull form and speed compared with previous vessels. There is every reason to suppose that Scandinavian constructors of standard tramps for either long or short term charter purposes are keenly alive to the technical improvements which have taken place in the building of vessels for the big oil companies, and that they are aware of the necessity of having something to offer for charter which, both as regards speed and fuel consumption, shall be at least as attractive as anything which the oil companies themselves own.

Holland is building nine tankers of 54,620 tons gross and Italy two of 22,000 tons. These latter are fast ships with a service speed of about 14 knots. Japan is building six tankers, totalling 29,180 tons gross, five of which are the fast trans-pacific type of motorship with unusual speeds and loading facilities. The Spanish figures are perhaps doubtful, but they show three of 20,220 tons gross to be under construction. In spite of the disturbances in that country a certain amount of building has been maintained, although the classification societies have had to withdraw their surveyors.

At the end of the year there were ten tankers constructing in American shipyards, having a total of 79,840 gross tons, and as usual the steam tonnage exceeded the Diesel figure. American shipyards have created a new technique in the powering of tankers with high-pressure water tube boilers and geared turbines, an arrangement which is causing considerable interest and thought in European circles and has resulted in taking the matter a stage further on the part of Swiss engineers who have produced a scheme for powering a large tanker with a Velox steam generator and Turbloc self-contained geared turbine unit which is smaller power-for-power at about 4,000 b.h.p. than the corresponding Diesel plant with a double-acting two-cycle engine. Whether advantage can be taken of the small machinery space so created is another matter, and a revision of



Streamlined superstructures as adopted by Scandinavian owners differ radically from deck erections of American vessels.

tonnage regulations is a subject which tanker men will have to press within the next decade.

A few years ago, in the United States, speeds varying from 9 to 11 knots were considered sufficient but today it is the opinion that commercial vessels may operate economically at 13 knots, with a possibility of increasing to 14 or 14½ knots in the not-so-distant future. Average speed of American-flag tankships attained under loaded seagoing conditions is about 11 knots. Most of the new tankers have rated speeds of from 12 to 13 knots. In keeping with standard practice only six of these ships are Diesel propelled, while two have been designed with turbo-electric drive and another is to be propelled by reciprocating steam engines. The remaining 27 are driven by steam turbines with double-reduction gears. Diesels are increasing in favor for boats operating on inland waterways and a half-dozen such tankers from 600 tons to 2,461 tons deadweight were fitted with that type of motive unit, as well as a number of smaller vessels. During the eighteen months under review about three score self-propelled and dumb barges, having a probable cost of over $1,000,000, were contracted for.

Several of the smaller vessels are of interest. The 2,461-ton TRANSOIL, launched last year from the Ingalls yard for National Petroleum and Transport Company, was built on the bracketless system with modifications by George B. Drake, naval architect. Powered by twin Diesels of 475 h.p. each, she operates at 9 to 10 knots along the Atlantic Coast, New York State Barge Canal and Great Lakes. She has two longitudinal bulkheads and a deep girder is installed along her centerline as strength member and wash plate in the large center tanks. Her design is such that she may be used for oil carriage one way and automobile transport on return trips. Her capacity is 20,500 bbl. in main tanks and 1,200 bbl. in reserve tanks, while bunkers hold fuel for 19 days' running. Although not constructed as an ice-breaker the TRANSOIL has been used as a battering ram for clearing a way for smaller boats through the ice-bound canal, her welded construction standing up under a strain which probably would have sprung the seams and butts of riveted plating.

Growing demand for gasoline in sections of Idaho, eastern Oregon and Washington which can be easily served by bulk stations at the head of navigation on the Columbia River has rendered economic a run formerly not commercially feasible. Inland Navigation Company ordered from Lake Washington Shipyard a vessel designed especially to suit the peculiar requirements of this run. The total cost of this vessel, the INLAND CHIEF, will be $227,240. She is about 1,000 tons deadweight and is a combination freighter and tanker, intended to carry bulk gasoline from Portland, Oregon, up the river to Pasco, Washington, and return with dry cargo consisting of baled wool and farm produce.

POLING BROS. NO. 14, all welded 600-ton Diesel tanker of Chester A. Poling Incorporated, is probably the first and only streamlined tankship constructed in the United States. The effect is produced by a low, slightly raked stack and by the fairing of the wheel-house roof, which slopes symmetrically over the captain's stateroom.

Among orders in sight, Union Oil Company of California is reported to have postponed for a few months the placing of contracts for three or four tankers, while General Petroleum Company of California is understood to be considering construction of two 15,000-ton deadweight tankers designed on the Arcform principle. Further replacements of older vessels in the Jersey Standard and other fleets are called for while there is again possibility of tanker construction by the U. S. Navy Department, since plans are being made for another drive for Congressional appropriations for building naval auxiliaries.

One of the major factors governing the future is the increased use of welding. This is especially the case so far as America is concerned, as it is probably in that country that the greatest development has been attained. Welding of cargo lines to take the place of flanges and bolts has not only brought about a saving in weight but has effected a greater guarantee against leakage. Use of electric-arc welding in tankship building was at first applied to piping, bulkheads, bracket connections and the like in larger vessels, while only small tankers and oil barges were welded in entirety. As these were proven to be superior as regards oil-tightness and maintenance so was the size of the vessels to which welding was applied increased, so that now tankers of 18,000 tons are being welded throughout.

Welded construction effects a number of savings: hull weight is appreciably reduced, which in turn permits greater cargo deadweight capacity on given displacement or permits reduction in displacement corresponding to hull weight saving and in reduced fuel consumption per deadweight ton. Another factor is that leakage due to collision is less than that of a riveted ship, due to flexibility and adhesion of welded seams, whereas open fractures may frequently appear when riveted plates are buckled.

Importance of hull lines has been recognized for some years but increased attention has been paid to them of late and special hull construction is much to the fore in recent orders. Appreciable increases in both speed and cargo capacity may thus be obtained. The Isherwood Arcform hull is especially popular with American owners for vessels built domestically and abroad. It is claimed that this form reduces resistance which exists by reason of the sharp bilge without reducing displacement or filling out the ends. Whereas American owners tend to Arcform hull Scandinavian owners seem to be going in for Maierform hull, which is understood to have given satisfactory results in service with somewhat increased speed and capacity. As yet this hull form has not been a feature of any American orders. A few tankers are being built in the United States with Frear-Bethlehem hull form, incorporating for the first time fluted bulkheads, which are built up of welded panels of plating of a pressed or dished character. It is claimed that a substantial saving in weight and particularly

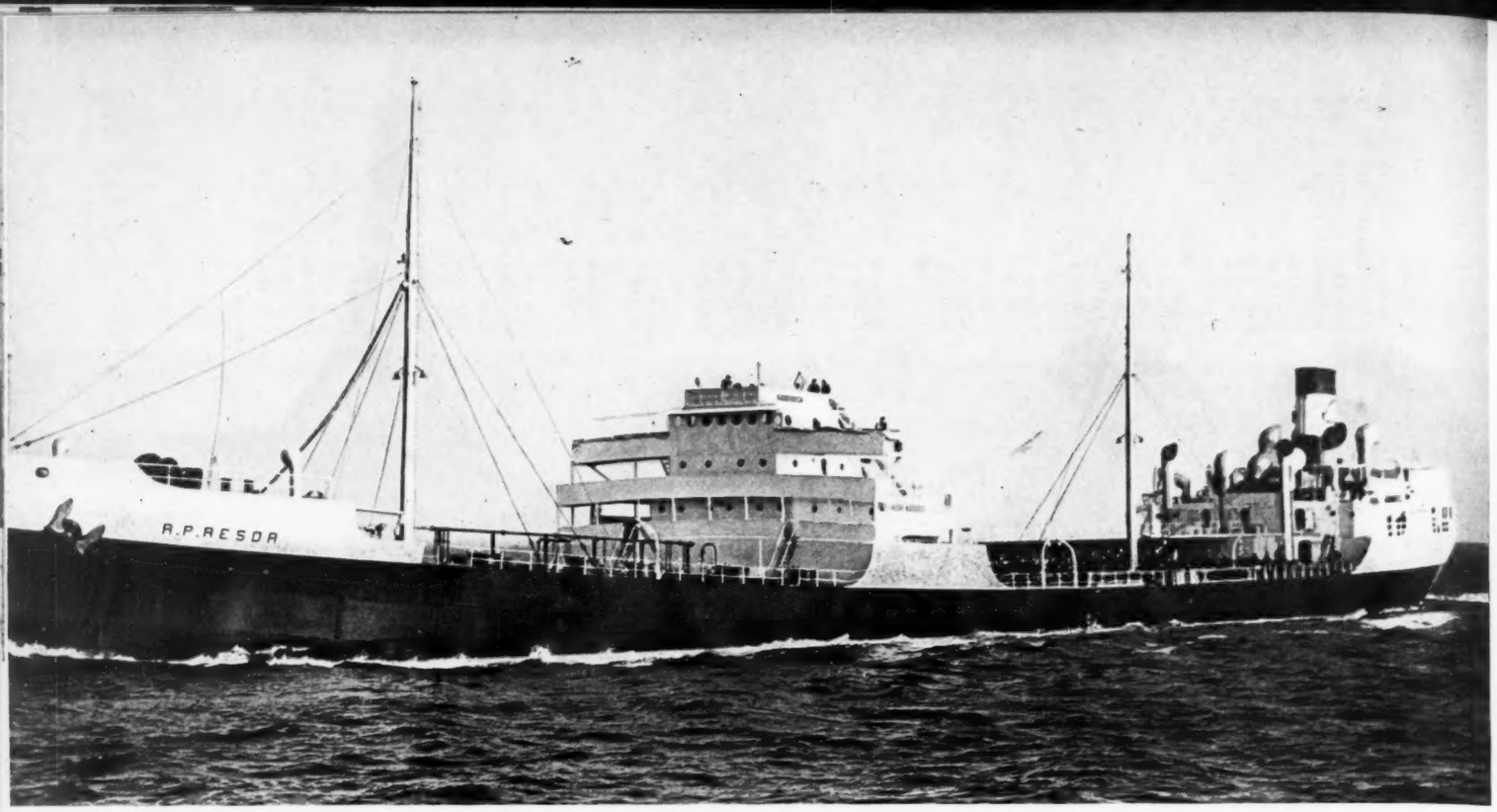
Tankers Under Construction and on Order Throughout the World

Owner	Number of Vessels	Builder	Length in feet	Breadth in feet	Depth in feet	Loaded Draft in feet	Tonnage	Engines	Horsepower	RPM	Speed
Standard Oil Co. of N. J.	4	Federal S. B. & D. D. Co.	440 B.P.	66½	34½	28	12,800 d.w.	De Laval Turbines	3,000 s.h.p.	90	12¾
Standard Oil Co. of N. J.	2	Sun S. B. & D. D. Co.	442 B.P.	65	35	28½	12,900 d.w.	Westinghouse Turbines	3,500 b.h.p.	85	13
Standard Oil Co. of N. J.	4	Bethlehem S. B. Corp.	442 B.P.	64	34⅝	28½	13,000 d.w.	Bethlehem Turbines	3,500 s.h.p.	85	13
Standard Oil Co. of California	2	Sun S. B. & D. D. Co.	442	65	35	28½	12,800 d.w.	Westinghouse Turbines	3,500 b.h.p.	85	13
The Texas Corp.	3	Sun S. B. & D. D. Co.	465	65	34¼	27¾	12,630 d.w.	Sun-Doxford Diesels	4,850 b.h.p.	90	13½
Atlantic Refining Co.	2	Sun S. B. & D. D. Co.	522	70	40	29½	18,000 d.w.	G. E. C. Turbo-Electric	5,000 b.h.p.	90	13+
Sun Oil Co.	1	Sun S. B. & D. D. Co.	511	65¾	37	29¾	15,800 d.w.	Sun-Doxford Diesel	5,400 b.h.p.	110	13½
Sun Oil Co.	1	Sun S. B. & D. D. Co.	522	70	40	30⅛	18,360 d.w.	Sun-Doxford Diesel	6,000 b.h.p.	90	14
Standard Oil Co. of Indiana	1	Manitowoc S. B. Corp.	454	55	28	....	9,000 d.w. Approx.	Reciprocating Steam	2,500	...	....
Gulf Oil Corp.	3	Bethlehem S. B. Corp.	442 O.A.	64	34	27½	11,000 d.w.	G. E. C. Turbines	3,000	78	12
California Standard Oil Co., Ltd.	1	Henry Robb, Ltd.	130	26	13¼	11⅛	600 d.w.	National Diesel	240 b.h.p.	300	7
Standard Oil Co. of California	1	Fried Krupp.	512	68	39½	29⅝	17,150 d.w.	Krupp Diesel	4,800 b.h.p.	118	12
Standard Oil Co. of California	1	Wilton Fijenword	460	59	34	27½	12,100 d.w.	Wilton Diesel	3,600 b.h.p.	...	12
Standard Oil Co.	2	Blohm & Voss	...	..	..	....	15,000 d.w.	Krupp Diesel	3,600 b.h.p.	...	....
Socony Vacuum	2	Deutsche Werft	483½	65¾	35¾	28½ Approx.	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	12
Standard Oil Co. of N. J.	1	Cantieri Riuniti dell' Adriatico	...	..	..	....	14,900 d.w.	FIAT Diesel	3,600 b.h.p.	...	12½
Standard Oil Co. of N. J.	1	Fried Krupp.	496¾	69¾	37	29½	15,000 d.w.	Krupp. Diesel	3,600 b.h.p.	110	12½
Standard Vacuum Oil Co.	1	Fried Krupp.	496¾	69¾	37	29½	14,900 d.w.	Krupp. Diesel	3,600 b.h.p.	110	12½
Standard Vacuum Oil Co.	1	Rotterdam D. D. Co.	485	69¾	37	29½	10,630 g.r.	Krupp. Diesel	3,600 b.h.p.	115	12½
Socony-Vacuum Oil Co.	1	Odeuse Staatsbibaveerft	...	..	..	....	10,400 d.w.	Barsig Steam	2,800 i.h.p.	...	....
Socony-Vacuum Oil Co.	1	Cantieri Riuniti dell' Adriatico	...	..	..	....	14,900 d.w.	FIAT Diesel	3,600 b.h.p.	...	12½
The Texas Corp.	1	Deutsche Werft	495	67	34⅛	27½ Approx.	14,000 d.w.	M. A. N. Diesel	5,100 b.h.p.	166	13½
The Texas Co. (Oslo)	1	Deutsche Werft	522	67	34⅛	27½ Approx.	14,000 d.w.	M. A. N. Diesel	5,100 b.h.p.	166	13½
Royal Dutch Shell Group	1	Rotterdam D. D. Co.	425	54¼	31	25⅔	9,140 d.w.	Werkspoor Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Rotterdam D. D. Co.	460	59	34	27½	1,200 d.w.	Werkspoor Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	2	Van der Piessen & Zonen	425	54¼	31	25½	9,100 d.w.	Werkspoor Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Wilton Figenoord	425	54¼	31	25½	9,100 d.w.	Wilton Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	2	Wilton Figenoord	425	54¼	31	25½	9,000 d.w.	Wilton Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Nederlandsche Dolz. Mij.	425	54¼	31	25½	9,000 d.w.	Werkspoor Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Nederlandsche Dolz. Mij.	...	..	..	....	4,000 d.w.	Steam	.....	...	....
Royal Dutch Shell Group	1	Odeuse	425	54¼	31	25½	9,150 d.w.	Werkspoor Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Cantieri Riuniti dell' Adriatico	425	54¼	31	25½	9,000 d.w.	Cantieri Riuniti Diesel	2,800 b.h.p.	120	12
Royal Dutch Shell Group	1	Cammell Laird & Co., Ltd.	425	57	32	26¼	9,500 d.w.	Hawthorne Leslie Diesel	3,500 b.h.p.	120	12¼
Royal Dutch Shell Group	1	Blythswood S. B. Co., Ltd.	460	59	34	27½	12,100 d.w.	Kincaid Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	1	Blythswood S. B. Co., Ltd.	...	..	..	....	4,000 d.w.	Atcheson, Blair, Ltd., Steam	.....	...	....
Royal Dutch Shell Group	2	Nederlandsche Sch. Mij.	460	59	34	27½	12,000 d.w.	Werkspoor Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	1	Konenklijke Mij de Schelde	460	59	34	27½	12,000 d.w.	Werkspoor Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	1	Bremer Vulkan	460	59	34	27½	11,900 d.w.	M. A. N. Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	1	Deutsche Werft	460	59	34	27½	11,900 d.w.	M. A. N. Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	2	Fumeso S. B. Co., Ltd.	...	..	..	....	4,000 d.w.	Steam	.....	...	....
Royal Dutch Shell Group	1	Nederlandsche Sch. Mij.	460	59	34	27½	12,000 d.w.	Werkspoor Diesel	3,500 b.h.p.	120	12
Royal Dutch Shell Group	3	Nederlandsche Sch. Mij.	335	56	14¾	13½	4,000 d.w.	Werkspoor Steam	2,400 i.h.p.	175	11
Royal Dutch Shell Group	1	Rotterdam D. D. Co.	325	49½	15	13¾	3,250 d.w.	Rotterdam D. D. Steam	2,400 i.h.p.	180	11½
Eagle Oil & Shipping Co., Ltd.	1	Blythswood S. B. Co., Ltd.	460	59	34	27½	12,000 d.w.	Kincaid Diesel	3,500 b.h.p.	120	12
Eagle Oil & Shipping Co., Ltd.	2	Lithgows Ltd.	460	61	33¼	27½	12,000 d.w.	Kincaid Diesel	3,500 b.h.p.	120	12
Anglo-Iranian Oil Co., Ltd.	6	Harland & Wolff, Ltd.	463	61⅛	34	27½	12,250 d.w.	Harland & Welpp. Diesel	2,850 b.h.p.	105	12
Anglo-Iranian Oil Co., Ltd.	2	Lithgows, Ltd.	464	61¾	34	27½	12,250 d.w.	Kincaid Diesel	2,850 b.h.p.	105	12
Anglo-Iranian Oil Co., Ltd.	1	Cammell Laird & Co., Ltd.	464⅛	61¾	34	27½	8,402 g.r.	Doxford Diesel	2,850 b.h.p.	95	12
Anglo-Iranian Oil Co., Ltd.	2	Swan, Hunter & Wigham Richardson, Ltd.	464	61¾	34	27½	12,250 d.w.	Doxford Diesel	2,850 b.h.p.	98	12
British Admiralty	2	Swan, Hunter & Wigham Richardson, Ltd.	464⅛	61¾	34	27½	12,250 d.w.	Doxford Diesel	2,850 b.h.p.	98	12
British Admiralty	1	Cammell Laird & Co., Ltd.	464⅛	61¾	34	27½	12,250 d.w.	Doxford Diesel	2,850 b.h.p.	95	12
Anglo-American Oil Co., Ltd.	1	Furness S. B. Co., Ltd.	...	..	..	....	5,400 d.w.	———	.....	...	....
C. T. Bowring & Co., Ltd.	1	Swan, Hunter & Wigham Richardson, Ltd.	485	66½	35	28¼	14,500 d.w.	Kincaid Diesel	.....	...	12¼
C. T. Bowring & Co., Ltd.	1	Swan, Hunter & Wigham Richardson, Ltd.	500	68¼	35¾	28⅝	15,000 d.w.	Diesel	.....	...	....
Crusader Petroleum Industries, Ltd.	3	Bremer Vulkan	470	63½	35½	28½	9,000 g.r.	Bremer Vulkan Diesel	.....	...	....
Crusader Petroleum Industries, Ltd.	4	Deutsche Werft	495	67	34⅛	27½ Approx.	14,000 d.w.	M. A. N. Diesel	4,100 b.h.p.	115	13
United Africa Co., Ltd.	1	Deutsche Werft	483½	65¾	32	28½ Approx.	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	12
United Africa Co., Ltd.	1	Deutsche Werft	500	68½	36½	29½ Approx.	16,000 d.w.	M. A. N. Diesel	4,500 b.h.p.	113	13

United Africa Co., Ltd.	1	Deutsche Werft	500	68½	36½	29½ Approx.	16,000 d.w.	M. A. N. Diesel	4,500 b.h.p.	113	13

Burmah Oil Co., Ltd.	1	Swan, Hunter & Wigham Richardson, Ltd.	335	54½	31	26½	7,800 d.w.	Doxford Diesel	.....	...	....
Leif Hoegh	2	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	13
Leif Hoegh	2	Odense	...	..	..	....	14,500 d.w.	B. & W. Diesel	4,700 i.h.p.	...	12
Phs. Van Ommeren's Sch.	1	Odense	...	..	..	....	14,500 d.w.	B. & W. Diesel	4,700 i.h.p.	...	12
Phs. Van Ommeren's Sch.	2	Van der Giessen & Zonsen	206	26¼	8⅛	7¼	660 d.w.	Stork Diesel	400 b.h.p.	310	9⅓
Thor Dahl	1	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	13
A/S Odd	1	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	13
Unilever, Ltd.	1	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	13
Unilever, Ltd.	1	Deutsche Werft	500	68½	36⅓	29½	16,000 d.w.	M. A. N. Diesel	4,500 b.h.p.	113	13
———	2	Deutsche Werft	500	68½	36⅓	29½	16,000 d.w.	M. A. N. Diesel	4,500 b.h.p.	113	13
Westfal Larsen & Co.	1	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	12
———	1	Deutsche Werft	483½	64¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	12
———	1	Deutsche Werft	198	32	15	14	1,200 d.w.	Krupp. Diesel	550 b.h.p.	185	9⅓
———	1	Deutsche Werft	460	59	34	27½	12,100 d.w.	M. A. N. Diesel	3,100 b.h.p. Approx.	120	12
The Skild Co., Ltd.	1	Bremer Vulkan	...	..	..	....	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	....
A. G. I. P. (Italy)	1	Ansaldo	505	68	..	27½	13,500 d.w.	FIAT Diesels	7,800 i.h.p.	...	14
A. G. I. P. (Italy)	1	Cantieri di Palermo	505	68	..	27½	13,500 d.w.	FIAT Diesels	7,800 i.h.p.	...	14
A. G. I. P. (Italy)	1	Cantieri Riuniti dell' Adriatico	505	68	..	27½	13,500 d.w.	Selzer Diesel	7,800 i.h.p.	...	14
A/S Dourofjell	4	Eriksberes Mek. Verk.	465	60¾	34	26¾	12,600 d.w.	Diesel	3,700 b.h.p.	125	12¾
Brovig-tank	1	Bremer Vulkan	483	65¾	36	28½	10,000 g.r.	Bremer Vulkan Diesel	.....	...	....
Sig. Bergesen D. Y. & Co.	1	Odense	...	..	..	....	15,350 d.w.	B. & W. Diesel	5,350 i.h.p.	...	12½
———	2	Odense	...	..	..	....	12,500 d.w.	B. & W. Diesel	5,680 i.h.p.	...	13½
———	1	Odense	...	..	..	....	12,500 d.w.	B. & W. Diesel	4,700 i.h.p.	...	12
A. P. Moller	1	Odense	...	..	..	....	14,500 d.w.	B. & W. Diesel	4,700 i.h.p.	...	12
Sigfurd Herlofsen	1	A. B. Gotaverken	487½	64	38⅛	29½	15,200 d.w.	Gotaverken Diesel	5,800 b.h.p.	110	14½
Sigfurd Herlofsen	1	Kockums Mek. Verks.	490	62¾	36½	28⅓	9,610 g.r.	Kockums Diesel	5,500 b.h.p.	120	14
Cie. Navale des Petroles	1	Ats. et Chantiers de France	553½	84	41¼	32⅛	21,000 d.w.	Chantiers Penhoet St. Nazaire Diesel	7,000 b.h.p.	120	13
Cie. Navale des Petroles	1	Ats. et Chantiers de France	411⅜	42¼	30⅞	20⅝	5,510 d.w.	Cie. de Fives Lille Steam	5,100 b.h.p.	120	15⅛
Cie. Navale des Petroles	1	Ats. et Chantiers de France	575	76	41	....	21,300 d.w.	Ch. et Qt. de St. Nazaire Diesel	7,300 b.h.p.	120	....
Dairen Kisen Kaisha	1	Harima Dockyard	...	..	..	....	4,000 g.r.	———	.....	...	13
Mitsubishi Oil Co.	1	Mitsubishi Kobe Dockyard	...	..	..	....	13,000 d.w.	Mitsubishi Diesel	.....	...	11
Mitsubishi Oil Co.	1	Mitsubishi Yokohama Dockyard	...	..	..	....	22,000 d.w.	Mitsubishi Diesel	.....	...	....
Yamashita K. K. Kaisha	1	Kawasaki Dockyard	...	..	..	....	13,000 d.w.	———	.....	...	....
Mitsui Bussan Kaisha	1	Mitsui Bussan Kaisha	488	65	36	....	9,200 g.r.	Mitsui Diesel	7,600 b.h.p.	...	16
Iino Shoji Kaisha	1	Kawasaki Dockyard	500	63	37	....	13,400 d.w.	Kawasaki Diesel	9,000 b.h.p.	125	17½
Y. P. F. (Argentina)	1	Hansen & Puccini	327	53	..	18	4,000 d.w.	Sulzor Diesel	2,400 b.h.p.	285	18
Y. P. F. (Argentina)	1	S. A. des Forges et Ch. de La Mediterranean	33	13⅛	5	2	12,500 Litres Capacity	———	.....	...	....
Y. P. F. (Argentina)	1	S. A. des Forges et Ch. de La Mediterranean	191	26	12⅛	10⅓	686	Diesel	400 e.r.	300^{T}_{M}	9
Y. P. F. (Argentina)	1	S. A. des Forges et Ch. de La Mediterranean	189¾	39½	16	12¾	1,250	Steam	900 e.r.	225^{T}_{M}	10½
Y. P. F. (Argentina)	1	S. A. des Forges et Ch. de La Mediterranean	82½	18⅓	8.5	5	41⅔	———	.....	...	....
Campsa	1	Cie. Euskalduna	461	62	..	27	10,900 d.w.	Maritima S.A. Diesel	3,600 b.h.p.	...	12¾
Campsa	1	Union Naval de Levante	461	62	..	27	10,900 d.w.	Maritima S.A. Diesel	3,600 b.h.p.	...	12¾
Campsa	1	———	...	..	..	....	5,000 d.w.	———	.....	...	....
J. T. Essberger	1	Deutsche Werft	483½	65¾	36	28½	14,500 d.w.	M. A. N. Diesel	4,100 b.h.p.	116	12
Hans Hannevig	1	Deutsche Werft	528	68½	36⅓	29½	15,500 d.w.	M. A. N. Diesel	4,500 b.h.p.	113	13½
Martin Mosvold	2	Burmeister & Wain	470	65⅙	35⅓	28¼	9,350 g.r.	B. & W. Diesel	4,600 b.h.p.	155	....
Hansen-Tangen Rederi A/S	1	Burmeister & Wain	470	65⅙	35⅓	28¼	9,350 g.r.	B. & W. Diesel	4,600 b.h.p.	155	....
Skibs. A/S Athos (Bernard Hansen)	1	Burmeister & Wain	455	61	35	27	8,150 g.r.	B. & W. Diesel	3,900 b.h.p.	155	....
Thorvald Berg (A/S Tank Transport)	1	Hamburg Yard	...	..	..	....	14,500 d.w.	B. & W. Diesel	4,000 b.h.p.	...	....
Rederi A/B Semo	1	Eriksbergs Melz. Verks.	137	24¾	11½	10⅔	365 d.w.	Nydqrist & Holm Diesel	480 b.h.p.	325	10½
A/S Selvang	1	Kockums Mek. Verks.	490	62¾	36½	28⅓	9,160 g.r.	Kockums Diesel	4,500 b.h.p.	108	13
Skibs. A/S Asplund	1	Kockums Mek. Verks.	460	59½	34½	27⅓	8,070 g.r.	Kockums Diesel	3,450 b.h.p.	96	12
Tankrederi Gellon S. A.	1	Kockums Mek. Verks.	490	62¾	36½	28½	9,660 g.r.	Kockums Diesel	4,500 b.h.p.	108	13
———	1	Kockums Mek. Verks.	490	62¾	36½	28½	9,660 g.r.	Kockums Diesel	4,500 b.h.p.	108	13
A/S Ludwig Mowinckel	1	Deutsche Werft	528	68½	36½	29	16,000 d.w.	M. A. N. Diesel	4,500 b.h.p.	...	13½
A/S Havmoy (P. Meyer)	1	Kockums Mek. Verks.	490	62¾	36½	28¼	9,660 g.r.	Kockums Diesel	4,500 b.h.p.	108	13
Norwegian Owners	1	Sir James Laing & Sons, Ltd.	...	..	..	....	.....	Steam	.....	...	....
———	2	Furness S. B. Ltd.	...	..	..	....	.....	Steam	.....	...	....
Reederei Hugo Stinnes A. G.	3	Elsflether Werft	...	..	..	....	Small	———	.....	...	....

Shell interests have under construction in England a group of 20 "mosquito craft," light-weight tankers for refuelling flying boats, at the Dunston yards in Doncaster, Rowhedge Iron Works in Colchester, and Thornycroft yards, Southampton. These boats will have speeds of 7 to 8 knots, the light displacement being 151¼ tons and dimensions 50 ft. in length, 10 ft. beam, 8¼ ft. depth and mean loaded draft 3½ ft. Some will operate at 14 knots, and all are constructed to meet heavy weather conditions. Capacity of each is 2,500 Imperial gallons of gasoline and 200 gallons of lubricating oil, with pumping speed of 120 g.p.m. for fuel and seven to ten gallons per minute of lubricant. Six similar vessels are building at the Thos. Cook yards at Cairo for Nile service, and others have been ordered in France and Italy.



Construction of the R. P. Resor marked the beginning of Jersey Standard's replacement program.

effective resistance of fluid pressure is obtained without additional cost by means of the bulged form compared with conventional riveted bulkheads.

Improvements in hull form are affecting the general appearance of European-built tankers. There is an increased tendency to streamlines and the box-like navigating house is rapidly disappearing from vessels of all but conservative owners. Stems are raked, sheers are greater, the midship navigating house has been virtually re-designed upon modern lines as is indicated by the picture of the BASILEA, reproduced on another page. Structures aft are likewise streamlined and this naturally calls for a squat raking funnel and cruiser or spoon stern. It is claimed than an appreciable reduction in air resistance and corresponding saving in fuel has been effected in practice. Streamlining of deck erections does not as yet seem to have made any headway in the American tanker industry, despite its rapid development in other fields of endeavor.

Many tanker men question the benefits of streamlining a vessel's superstructure for speeds of less than 16 knots and it is pointed out that air resistance of life-boats, ventilators, masts and rigging present a further problem in that they would be expensive and difficult to streamline. Without actually having adopted even a modified streamlining, one important owner of American-flag tankers has realized the necessity of reducing the appreciable wind resistance brought about by large, flat bridge-housing and has therefore made a point of designing all its vessels so as to eliminate as much of this as possible by having few bridge decks and not having the large flying bridge found on so many conventional vessels.

The Diesel engine as compared with the old steam plant aids in producing this modern streamlined profile, but between Diesels and modern steam turbines there is little to choose. It becomes a moot point, however, as to whether this type of machinery can get down to the Diesel as regards cost and there is of course a technique in the operation of Diesel tankers which has been built up throughout the world and which would require alteration were a somewhat revolutionary type of steam plant substituted.

Powers for vessels up to about 12,000 tons capacity have not greatly exceeded 3,000 b.h.p. and although there is a marked tendency to push the loaded speed beyond 12 knots this is not yet general. The old adage that a bulk cargo necessitates a slow speed is rapidly being proved incorrect, for it is recognised with all types of vessels that the faster the individual unit the fewer units employed and the larger number of voyages the individual can make in the course of the year. It would seem that sooner or later the tanker world will have to take cognizance of this fact, although American theories have undergone an abrupt turn-about of late.

Another noticeable development is that the twin-longitudinal bulkhead tanker has become very popular and has begun to supersede the single centerline bulkhead vessel. Advantages claimed for this arrangement are that increased longitudinal strength is obtained, together with more flexibility in loading and trimming the vessel and use of only center tanks for water ballast. There is also a direct saving in steel and a smaller area of plating is liable to corrosion.

Pumping speeds have advanced to a marked degree and two 18,000-ton tankers now building will discharge at 15,000 bbl. per hour—a new record.

American oil company tanker owners continue to combat corrosion—cancer of the tankshipping business. Those with large fleets carry out experiments of their own, cooperating of course with the A.P.I. subcommittee on corrosion, while smaller operators must rely solely on the findings of that organization. All methods are dealt with: design, metalization, alloy metals, and protective coatings. Some consider that ultimate prevention of corrosion in tankers will be by means of an alloy steel, but this is a matter for the future to disclose. One of the obstacles of certain alloys already developed is the prohibitively high cost; whether or not this cost will be reduced in the next few years is a matter of conjecture.

Problems encountered in protection of oil cargo tanks are peculiar to this type of vessel, as distinct from other cargo ships, and so far no truly satisfactory tank-lining paint has been evolved. One counter-active against this serious problem may very well turn out to be a vegetable oil, or derivative thereof, for it has been observed in practice that corrosion of cargo tanks has been reduced to negligible quantities, hardly more than a mill-scale, after carrying vegetable oil, this condition of resistance to attack from corrosive constituents of petroleum and salt water being maintained over a period of four years as compared with rapid corrosion in sister-ships on the same route carrying petroleum only. Vegetable oils may have certain properties which enable them to work their way into the metal and protect it—although not all are in agreement with this theory as to its protective qualities—their action being somewhat similar to that of lubricating oil, which is known to have a preservative effect upon cargo holds in tankers. As yet this method of corrosion prevention by vegetable oils has not been fully

Gulf Oil Corporation is another company replacing obsolescent units of its tanker fleet.

investigated, but considerable scope would appear to exist for those interested and willing to spend the time necessary to carry out exhaustive experiments by thus impregnating the steel in oil cargo tanks for varying periods and testing the results.

It has been claimed that corrosion is appreciably retarded by maintaining in the tanks an atmosphere of inert flue gases or CO_2, thereby excluding oxygen that must be present for corrosion to take place. It is generally recognized that maintaining tanks free of sediment and loose scale has a favorable effect upon the life of a tanker. Many owners employ the Butterworth System of tank washing to accomplish this. By this method tanks are cleaned to bare plating by washing the sides, tops, and bottoms with high-pressure jets of hot water. Breaking up and removal of loose and semi-loose scale prevents the presence of concealed oil, salt water, or any other substance which might have a deteriorating action upon the metal and which would not be removed by ordinary manual methods of washing down. Draining of the tank's bottom during these operations permits full force of the hot water to play upon the bottom plates, which results in better draining and consequent corrosion retardation. Water at 165 deg. F. and 175 lbs. pressure is used.

It has been suggested that naval architects, in drawing up plans for new vessels, should make provisions for fitting and use of such mechanical washing apparatus (already installed on some 400 tankers). Inclusion of these features in architects' drawings and specifications would add little, if at all, to the cost of construction. Unfortunately, this is not always given the attention it deserves by members of the profession, with the result that at a later date a larger pump, larger fire line, and a water heater must be installed, and the tanks gas-freed to permit cutting of holes through the deck plates. It is believed that the only added expense of fitting tankers with this system while still on the stocks is that of installing a high-pressure heater on the fire line.

Some of the advantages obtained by use of this system are: elimination of steaming with its consequent danger to life; damage to hull paints and structure due to excessive and unequal expansion normally caused by steaming tanks; prevention of steam and explosive gases escaping on deck; elimination of the hazardous practice of sending workmen into tanks for cleaning, and of the necessity for paying the crew overtime for this work; its cost of operation is less than that of cleaning tanks manually, while the saving in time required for conversion to handle different cargoes renders the ship's operation more flexible—a boon to vessels in competition on the open charter market.

Another suggestion recently made was for improving tanker accommodations—that natural ventilation should be replaced by an air-conditioning system of simplified air-washing type. In extreme climates this would be an improvement, and would add comparatively little to the vessel's cost and operating expenses and would eliminate a fire hazard in the form of electric fans.

America's first streamlined tanker.

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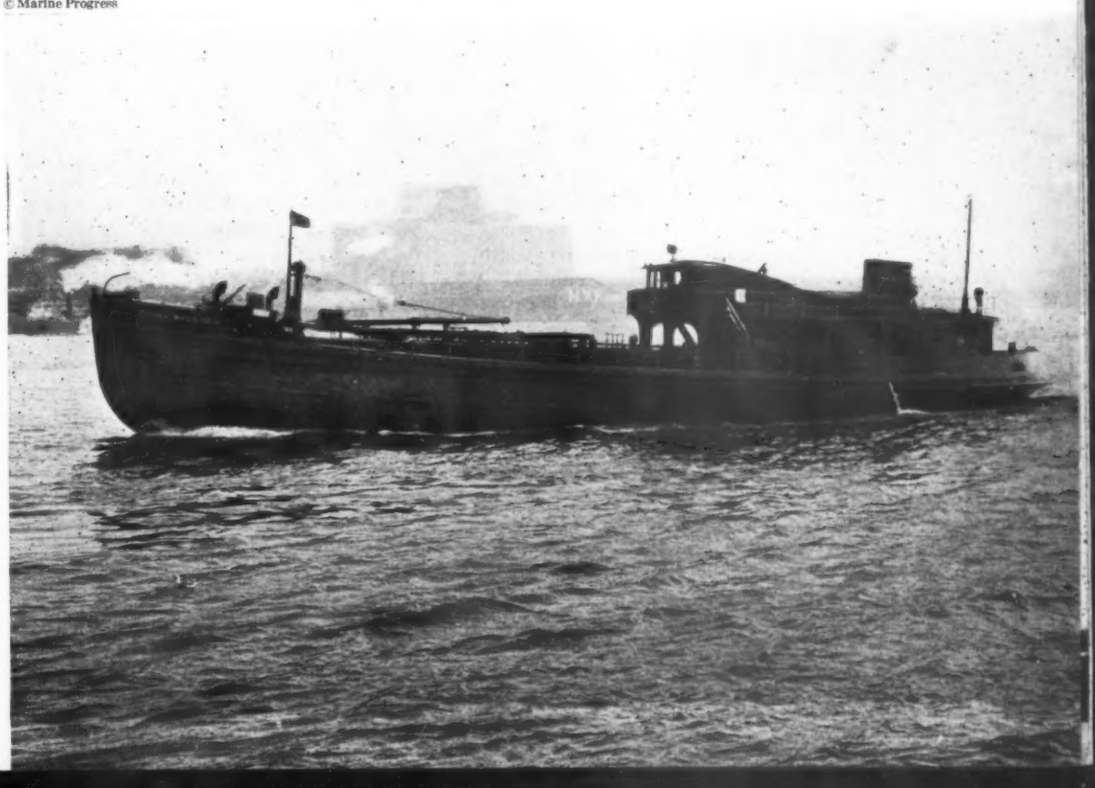


Contra guide rudders are installed on several of Jersey Standard's new vessels.

PROPELLING MACHINERY FOR TANK SHIPS

By Robert W. Morrell

In the issue of World Petroleum of November, 1931, the writer was privileged to discuss the peculiar problems involved in the selection of propelling machinery for tankers. These problems involve the characteristics of oil cargoes carried in bulk in tank vessels, which place propulsion design of tankers somewhat apart from the realm of pure naval architecture and marine engineering and place tankers in a class by themselves. In this respect, tankships form a close bond between the marine and petroleum industries.

It is not the intention in the present writing to review the factors referred to above. The basic problems of water-borne transportation of petroleum and its products are essentially the same today as they were in 1931. Rather, it is the purpose of these pages to analyze the actual trend of tankship construction during the last few years, as reflecting the application of modern thought to these special problems in propulsion of marine petroleum carriers.

In the present discussion, applying to self-propelled tankers of the United States, these vessels are grouped under three headings: sea-going or deep-sea tankers; coastwise tankers; and tankers for harbor and inland waters.

Considering first the sea-going tankers, we find that these are of large size, ranging (in recent construction) from about 9,500 tons to 20,600 tons deadweight carrying capacity. They represent an enormous investment, averaging somewhat over $130 per deadweight ton; therefore their efficiency and refinement of design is of a high order.

Twenty-six of these sea-going tankers have been built in the United States since 1930, and 21 more are now under construction or on order, making a total of 47 large, modern tankships. Of these 47 sea-going tankers, 16 are motorships, all built or building by Sun Shipbuilding and Dry Dock Company,

Chester, Pa., and equipped with Sun-Doxford Diesel engines. They consist of the following:

1. Six vessels of the CHESTER SUN class, built in 1930–31 for the Motor Tankship Corporation.

The propelling machinery of each consists of a five-cylinder opposed-piston two-stroke cycle reversible oil engine rated at 2,800 s.h.p. at 80 r.p.m. Cylinder bore is 23.62 ins. and stroke is 2 by 45.66 ins. Each engine has a 62¼ ins. by 41 ins. scavenging pump, driven direct from the crank shaft.

Electric power is derived from two 75 k.w. 240 volt D.C. General Electric Co. units, each having a 120 b.h.p. Diesel engine drive, four-cycle, four-cylinder, 8¼ ins. by 12 ins., of Cooper-Bessemer make. Either one will carry the load. There is also an auxiliary generator, 20 k.w., 240 volt D.C., driven by an 8 ins. by 6 ins. steam engine; all of General Electric make. There are also two rotary balancer sets for 240 to 120 volts.

Each vessel has two air compressors; one vertical of Worthington make, 90 c.f.m. capacity, driven by a 45 h.p. General Electric motor, and one vertical type, 150 c.f.m. capacity, driven by a 10 ins. by 12 ins. vertical steam engine.

The bunker fuel capacity is 312,750 gal.

Interesting performance data have been published for these vessels for several loaded voyages from San Pedro, Cal., via the Panama Canal to the Delaware Capes, which may be summarized as follows:

Performance Data

Displacement, tons	19,730 to 20,307
Speed, knots	10.24 to 11.76
S.h.p.	2610 to 2690
R.p.m.	76.5 to 79.7
E.h.p.	1621 to 2070
Propulsive coefficient (e.h.p.÷s.h.p.)	.621 to .7696
Fuel for all purposes, bbl. per day	70.4 to 82.7

2. The 16 motor tankers mentioned above also include the BRILLIANT, COMET and DAYLIGHT, built for the Standard Transportation Co. in 1930–1931. These three vessels are very similar to the six just described.

In 1935, the DAYLIGHT made a round-the-world voyage, of which the designers and builders are justly proud. Figures as reported showed the total distance as 30,390 nautical miles; total time at sea, 123 days, 12 hours, 58 minutes; average speed (ordered), 12¼ knots; average daily fuel consumption, all purposes, 11.55 tons.

3. Also among the 16 motor tankers are the TIDEWATER and TIDEWATER ASSOCIATED, likewise built in 1930. These vessels, too, are very similar in dimensions, capacity, power and speed to the other nine Diesel tankers just referred to.

Prior to June, 1934, they were engaged chiefly in transporting crude oil from the Gulf to Bayonne, N. J., making a round-trip voyage of about seventeen days. Their average speed was 10.79 knots with 76.5 r.p.m. and 2,800 s.h.p. for the TIDEWATER and 10.6 knots with 78.2 r.p.m. and 2,900 s.h.p. for the TIDEWATER ASSOCIATED. Average fuel consumption for all purposes was 77.5 bbl. per day, and average lubricating oil consumption 14.15 gal. per day, per ship.

The foregoing eleven similar motor tankers constitute those built during that period, and are the most modern U. S. Diesel tankers now in ocean service.

4. In addition to these, there is one motorship, the TEXAS SUN now building for the Sun Oil Company which has some of the characteristics of this previous class, but is an enlargement and improvement upon its predecessors. She was launched March 24, 1937.

In developing this improved type the designed power and speed have been materially increased. The new vessel will have a Sun-Doxford Diesel engine of 5,600 s.h.p. at 100 r.p.m., with an estimated speed of 13½ knots.

5. The Sun Oil Co. has also placed an order, in February, 1937, for an additional motor tanker. This is to have a length between perpendiculars of 542 ft. 5 ins.; beam 70 ft.; depth 40 ft.; load draft 30 ft. 2 ins.; deadweight capacity 18,360 tons. It will be powered with a five-cylinder 6,000 b.h.p. Sun-Doxford Diesel engine.

6. The Texas Co. has three Diesel tankers under construction; two contracted for in July, 1936, and the third in December, 1936. These are sister ships, but are not duplicates of the CHESTER SUN class. The new vessels have a length between perpendiculars of 465 ft.; beam 65 ft.; depth 34 ft. 3 ins.; load draft 27 ft. 9 ins.; displacement 17,985 tons; deadweight capacity 12,630 tons; cargo capacity, 100,000 bbl.

The propelling machinery will be a Sun-Doxford engine developing 4,850 s.h.p. at 100 r.p.m., with a designed speed of 13½ knots.

This completes the 16 motor tankers referred to; eleven of them, very much alike, built in 1930–31, and five in the current program. It is interesting to note the increase in speed from the 11 knots of the earlier group to the 13½ knots of present design.

Now as to the tank steamers of the 1930–1937 period. We have seen that these years developed 47 ocean tankers of which 16 are motorships; the balance, or 31, are steamers. These consist of the following:

1. VIRGINIA SINCLAIR and HARRY F. SINCLAIR, JR., built by the Fore River Plant of the Bethlehem Shipbuilding Corp. for the Sinclair Navigation Co. in 1930–31. These vessels have a length between perpendiculars of 416 ft.; beam 57 ft.; depth 32 ft.; load draft 25 ft. 6¾ ins.; displacement, 13,225 tons; deadweight capacity 9,345 tons; cargo capacity, 68,000 bbl.

The propelling unit is a compound impulse type DeLaval turbine of 4,000 s.h.p., with double-reduction two-plane gearing. The high pressure turbine turns at 5,480 r.p.m., the low pressure turbine at 4,275 r.p.m. and the propeller at 75 r.p.m. The high pressure turbine has eleven stages and the low pressure seven. The backing turbine is included in the low pressure casing.

These ships each have three Babcock & Wilcox water-tube boilers, of 3,372 sq. ft. boiler heating surface, 371 sq. ft. superheating surface, 1,733 sq. ft. air-heating surface, per boiler; 400 lbs. per sq. in. working pressure and 750 deg. steam temperature. The superheaters are interdeck type. The boilers have B. & W. oil burners, with induced draft. Feed heating is in two stages, the low pressure heater taking exhaust from the steam auxiliaries and the high pressure taking steam bled from the seventh stage of the h.p. turbine. The steam of the air-ejector also heats the condensate. Feed temperature is about 300 deg. F. The main condenser is Bethlehem two-pass bent-tube type of 6,000 sq. ft. cooling surface.

There are two 60 k.w. 115 volt generators, driven by DeLaval turbines at 2,100 r.p.m.

The fuel bunker capacity is 7,000 bbl., each ship.

On their trials, these Sinclair vessels are reported to have made 13.305 knots on the measured mile, with 24 ft. 1 in. draft, 73.8 r.p.m., and 3,968 s.h.p. For the six-hour run, the record shows 75.5 r.p.m., 4,422 s.h.p., and fuel consumption of 0.668 lbs. per s.h.p. per hour, all purposes. A trial speed of 14.095 knots is also reported, with 24 ft. draft, 4,500 s.h.p., and 76 r.p.m.

The Transactions of the Society of Naval Architects and Marine Engineers for 1932 gives a record of performance of the VIRGINIA SINCLAIR for two long voyages, as follows:

Virginia Sinclair Performance Record

Average speed	13.55 knots
Average fuel-oil consumption per day at sea	132.4 bbl.
S.h.p., main engine	3251.
Average fuel consumption, all purposes, per s.h.p. of main engine, per hr.	0.607 lbs.

It is also noted that the cost of lubricating oil per year is given as $126.57. The average fuel-oil port consumption is stated to be 83.7 bbl. per day.

2. G. HARRISON SMITH and W. S. FARISH, built by the Federal Shipbuilding and Dry Dock Co. in 1930, for the Standard Oil Co. (New Jersey). These vessels have a length between perpendiculars of 525 ft.; beam 74 ft.; depth 40 ft. 6 ins.; loaded draft 30 ft. 7⅛ ins.; displacement 27,240 tons; deadweight capacity 20,615 tons; cargo capacity 154,000 bbl.

Each vessel has a main propelling unit consisting of a De Laval cross-compound turbine, the high and low pressure turbines being in series, and arranged in conjunction with single-plane double reduction gears, 5,480 r.p.m. for the high pressure turbine and 4,275 r.p.m. for the low pressure turbine to 75 r.p.m. for the propeller. Each unit is designed for 4,000 normal s.h.p. at 75 r.p.m. of propeller, with steam pressure of 375 lbs. per sq. in., steam temperature of 725 deg. F., and vacuum of 28¼ ins. For reversing, the astern turbine is in the low pressure casing and develops about 89 percent of ahead torque. High and low pressure turbines are of the impulse type, of eleven and seven stages respectively; with two stages for the astern turbine. The turbine design is very similar to that in the VIRGINIA SINCLAIR.

There are two B. & W. boilers, of 420 lbs. per sq. in. working pressure and 750 deg. F. total temperature. Heating surface is 5,080 sq. ft., superheating surface 903 sq. ft., air heating surface 3,460 sq. ft., per boiler.

© Stanolind Record

"Neither ice nor snow. . . ."

Superheaters are B. & W. interdeck type. Desuperheaters are fitted in the drums, to give saturated steam for auxiliaries. Boilers have oil burners and a balanced draft system combining forced and induced draft. Normal equivalent evaporation is stated as 6.25 lbs. of water per square foot of heating surface per hour, and the boiler efficiency as about 86.6 percent, with feed water temperature of 310 deg., although the actual feed temperature appears to be about 298 deg. F.

Feed heating is accomplished by a three-stage system, using steam bled from the turbines, also the discharge of the steam jet air pumps. The main condenser is two-pass of 3,920 sq. ft. cooling surface.

The bunker fuel capacity is 1,382 tons, each ship.

The performance of these two tankers for 1931–32–33, during which the G. HARRISON SMITH delivered 65 cargoes and the W. S. FARISH 59 cargoes, has been reported as follows:

Performance Records

	G. Harrison Smith	W. S. Farish
Average bbl. fuel per day, loaded	166.3	163.9
Average bbl. fuel per day, ballast	158.3	155.5
Average speed in knots, loaded	11.26	10.87
Average speed in knots, ballast	11.10	10.91
Average r.p.m., loaded	67.8	66.7
Average r.p.m., ballast	68.3	66.4
Average horse power—all purposes	3,940	3,801

The guaranteed fuel consumption of the SMITH and FARISH was 0.63 lbs. per s.h.p. per hour, for all purposes, at normal power. The builders have stated the fuel consumption to be actually about 0.60 lbs. per s.h.p.

3. In 1935 the Federal Shipbuilding and Dry Dock Co. designed and laid down two stock tank steamers which were purchased during construction by the Standard Oil Co. (N. J.) and named the R. P. RESOR and T. C. MCCOBB. These vessels have a length between perpendiculars of 435 ft.; beam 66 ft. 6 ins.; depth 34 ft. 6 ins.; load draft 28 ft.; displacement 16,750 tons; deadweight capacity 12,844 tons; cargo capacity about 123,000 bbl. The designed sea speed was 12 knots.

The propulsion turbines are of Allis-Chalmers cross-compound type, designed for normal steam conditions of 375 lbs., 725 deg. F., and 28½ ins. vacuum. Normal s.h.p. is 3,000 at 90 r.p.m. The h.p. turbine is of impulse-reaction type and the l.p. is of straight reaction type, with 11 stages. They have double reduction gears, 6,000 to 90 r.p.m.

There are two Foster Wheeler Type "D" water-tube main boilers, of 430 lbs. per sq. in. working pressure and 750 deg. F. steam temperature. Heating surface is 1,830 sq. ft., economizer surface 780 sq. ft., air heater-surface 1,300 sq. ft., per boiler. Superheater is bare-tube, convection type. Normal evaporation is 13,000 lbs. per hour, per boiler. Boilers have oil burners and forced draft, using pre-heated air. Boiler efficiency is stated as 87½ percent. Feed heating is accomplished by a three-stage system, using steam bled from the turbine. Main condenser is Worthington two-pass, deaerating type, with 3,000 sq. ft. cooling surface.

Bunker capacity is 645 tons.

4. In December, 1935, before the MCCOBB was delivered, the Pan American Petroleum Co. placed an order with Federal for two ships, practically duplicates of the RESOR and MCCOBB. These are the PAN-MAINE and the PAN-FLORIDA, completed in October and December, 1936, respectively.

5. Then in July, 1936, Standard Oil Co. (N. J.) contracted with the Federal yard for four more tank steamers of the same type, the main difference being that these four are five feet longer than the preceding four, thereby increasing the displacement and deadweight to some extent. The propelling turbine equipment in the newer steamers is De Laval, and approximates that of the FARISH rather than that of the MCCOBB. The h.p. turbine and pinion speed is 6,000 r.p.m., the l.p. speed, 5,000 r.p.m. and the reduction gearing is combined in a single casing. The propeller speed is 90 r.p.m. And the cargo piping system is somewhat different. Otherwise, the four later vessels are the same as the previous ships, in the principal features.

6. Going back to December, 1933, the Socony-Vacuum Oil Co. ordered two steam tankers at New York Shipbuliding Co., Camden, N. J.; the SOCONY VACUUM and the MAGNOLIA, delivered April and September, 1935, respectively. These two ships had a length between perpendiculars of 484 ft., beam 65 ft. 9 ins.; depth 37 ft.; load draft 29 ft. 8⅜ ins.; displacement 20,695 tons; deadweight capacity 15,285 tons; cargo capacity 127,000 bbl.; designed trial speed 13¼ knots, designed sea speed 12½ knots.

Propulsion in these ships is by a De Laval double-reduction geared-turbine designed for 4,000 s.h.p. at 75 r.p.m. propeller speed, with steam at 375 lbs. per sq. in. and 700 deg. F. and 28¼ ins. vacuum.

The h.p. turbine, running at 5,480 r.p.m. has one velocity-compound stage and 10 im-

pulse-stages. The l.p. turbine running at 4,275 r.p.m. includes ahead and astern elements, the ahead being of seven impulse stages. The astern turbine has two stages of velocity compound type and two of the impulse type.

Steam is supplied by three Foster Wheeler "A"-type water-tube boilers. Two of these are called main boilers, for propulsion. They have 425 lbs. working pressure and 700 deg. F. total temperature, and supply 19,000 lbs. of steam per hour each. Their heating surface is 3,407 sq. ft., superheating surface 2,800 sq. ft., economizer surface 2,304 sq. ft., furnace volume 544 cu. ft., per boiler. They have inter-deck superheaters, fin-type economizers, and desuperheaters.

The third boiler is called the cargo boiler and is designed for 400 lbs. working pressure but normally operates on 150 lbs. Its heating surface is 4,350 sq. ft. and furnace volume 610 cu. ft.

The boilers have Todd oil burners and forced draft. The main condenser is two-pass, with 4,543 sq. ft. cooling surface.

There are three main cargo pumps, rotary type, of 1,900 g.p.m. capacity each, driven by 140 h.p. turbines, through single reduction gears. There are also three summer rotary tank pumps, 1,050 g.p.m. each, driven by 80 h.p. turbines.

The steering gear is electric hydraulic ram type. Deck machinery is steam, and the auxiliaries are part steam and part motor driven.

The bunker capacity, main and reserve, is 1,365 tons.

As to performance, it is understood that on her sea trial the MAGNOLIA averaged 13.68 knots and developed 3,606 s.h.p. at 74.4 r.p.m.

7. The Socony-Vacuum Oil Co. followed these with two more steamers, built by Sun Shipbuilding and Dry Dock Co.; the MOBILOIL and MOBILGAS, completed in February and March, 1937. These are not of the same design as the SOCONY VACUUM; the later ships are slightly larger, having a length between perpendiculars of 485 ft. 6 ins.; beam 68 ft.; depth 37 ft.; load draft 30 ft.; displacement about 21,450 tons; deadweight capacity 15,500 tons; cargo capacity 131,500 bbl.; fuel capacity 1,280 tons.

They are each driven by a 4,000 s.h.p. turbine with double reduction gears, with 75 r.p.m. of propeller. Each ship has two water-tube boilers of 400 lbs. working pressure and 700 deg. F. steam temperature.

Daily fuel consumption at 12 knots sea speed is given as 25½ tons. At this rate, the steaming radius is 14,500 nautical miles.

8. Referring again to the new tank steamers of the Standard Oil Co. (N. J.), we find that the Sun Shipbuilding and Dry Dock Co. now has two under construction. These are 442 ft. in length (b.p.); beam 65 ft.; depth 35 ft.; load draft 28 ft. 4 ins.; displacement 17,125 tons; deadweight capacity, 13,000; cargo capacity, 105,000 bbl.

They have turbine drive, 3,000 s.h.p. at 90 r.p.m. Each has two water-tube boilers, 430 lbs. working pressure and 750 deg. F. steam temperature. The designed sea speed is 12 knots.

9. The Standard Oil Co. (N. J.) also has two tankers building at the Sparrows Point Plant of the Bethlehem Shipbuilding Corp. These were contracted for in July, 1936. A third sister ship was ordered in December, 1936. These three have a length (b.p.) of 442 ft.; beam 64 ft.; depth 34 ft. 10 ins.; load draft 28 ft. 2 ins.; deadweight capacity 13,000 tons.

Their propulsion is by geared turbines and the designed sea speed is 12 knots.

10. In addition to the two tankers built by Federal for the Pan American Petroleum Co., the latter company has had two built by Sun Shipbuilding and Dry Dock Co.; the PAN AMOCO and the PAN AMERICAN, completed in October and November, 1936, respectively. These are 485 ft. 6 ins. length b.p.; 68 ft. beam; 37 ft. depth; 29 ft. 10⅞ ins. loaded draft; 21,350 tons displacement; 15,400 tons deadweight capacity; 130,000 bbl. cargo capacity; 1,280 tons bunker capacity. These vessels are quite similar, in various details, to the SOCONY VACUUM and MAGNOLIA, and the description of the machinery installation of those ships applies here as well, in the essentials. The intended service speed is 13 knots.

The main differences are that the generators are larger in the later ships; two of 100 k.w. and one of 50 k.w. Also, the heating surface of the main condenser is 4,800 sq. ft.

11. The Gulf Refining Co. took delivery of the GULFBELLE and GULFDAWN from the Sun Shipbuilding and Dry Dock Co. in June, 1936. These are of 425 ft. length b.p.; 64 ft. beam; 34 ft. depth; 27 ft. 8¾ ins. loaded draft; 15,560 tons displacement; 11,400 tons deadweight capacity; 85,000 bbl. cargo capacity; 6,700 bbl. fuel capacity.

Propelling machinery for each consists of a 2,800 s.h.p. cross-compound impulse-reaction type turbine with double reduction gears, 4,820 to 78 r.p.m.

Each ship has two Foster Wheeler type "A" boilers; 2,901 sq. ft. boiler heating surface and 1,934 sq. ft. economizer surface per boiler. Working pressure is 400 lbs. and steam temperature 725 deg. F. Evaporation is stated to be 15,000 lbs. per hour, boiler efficiency 87 percent, CO_2 14 percent. Superheaters are of the inter-deck convection type. Oil burners have forced draft. Main condenser is two-pass, 4,000 sq. ft. cooling surface. There are two 125 k.w. 240 volt generators and one 25 k.w. turbine driven.

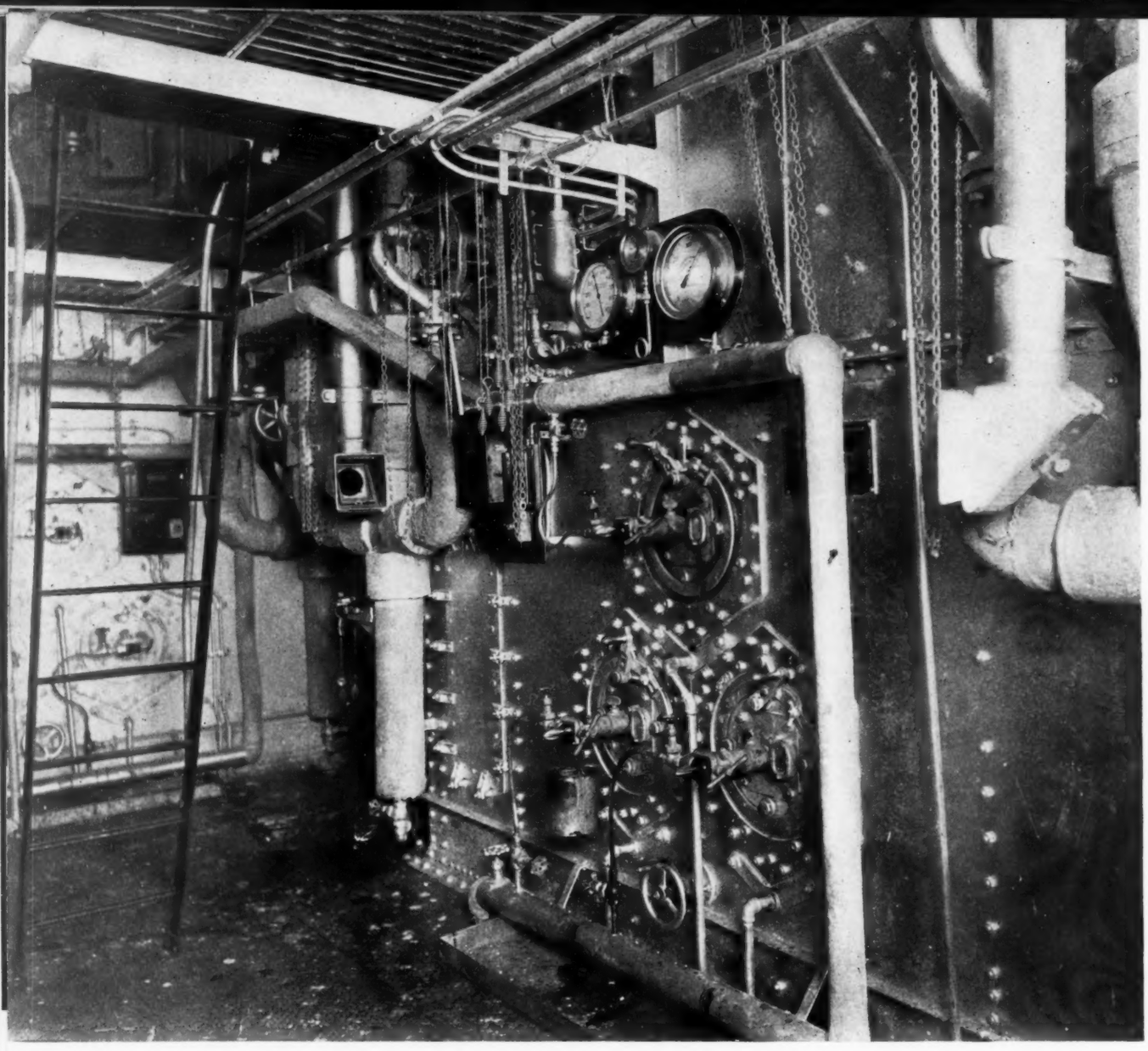
The Gulf Co. requirements involve cargo pumping equipment for handling several different grades of oil separately, in one cargo. There are ten turbine-driven rotary pumps, capable of discharging all cargo in 15 hours. The vessels were designed for 12 knots sea speed. It is stated that the GULFBELLE has averaged 13.9 knots loaded from Port Arthur, Texas, to Providence, R. I.

12. The Gulf Refining Co. also has the GULFCOAST and GULFTIDE, launched at the Sparrows Point Plant of the Bethlehem Shipbuilding Corp. in December, 1936, and January, 1937, respectively. In addition, they placed an order with Bethlehem in February, 1937, for two more ships. These are all sister-ships of the GULFBELLE, making six recent tank steamers of this GULF class.

13. Sun Shipbuilding and Dry Dock Co. has under construction a large tanker for the Atlantic Refining Co. This vessel has turbo-electric drive; the only one of the current construction program so equipped. This vessel is 522 ft. in length b.p.; 72 ft. beam; 40 ft. depth; 29 ft. 5 ins. load draft; 23,400 tons displacement; 18,000 tons deadweight capacity; 155,000 bbl. cargo capacity. A second vessel, very similar, was ordered in March, 1937.

The s.h.p. is stated to be 5,000 and the sea speed 13½ knots; but the details of the machinery installation have not been made public.

Part of Pan American Petroleum and Transport Company's new tanker fleet.



Foster Wheeler boiler installation on a modern turbine-driven tanker.

14. In December, 1936, the Standard Oil Co. of California placed an order with the Sun Shipbuilding and Dry Dock Co. for two tank steamers, duplicating the two building there for the Standard Oil Co. (N. J.), described in paragraph 8.

These modern floating steam plants present features which invite discussion which space will not permit. The notable feature of the new tank steamers is the almost universal adoption of turbine drive. Two vessels, as mentioned, will have turbo-electric propulsion; and one or two new tankers on the Great Lakes adhere to reciprocating main engines, for particular reasons of the service. But the preponderance of the modern tankers have high-pressure, high-temperature turbines with double reduction gears. They represent a development of the marine steam plant to a high degree of refinement in design and of efficiency in the heat-balance and fuel economy, which is close to 0.60 lbs. of fuel for all purposes, per s.h.p. per hour.

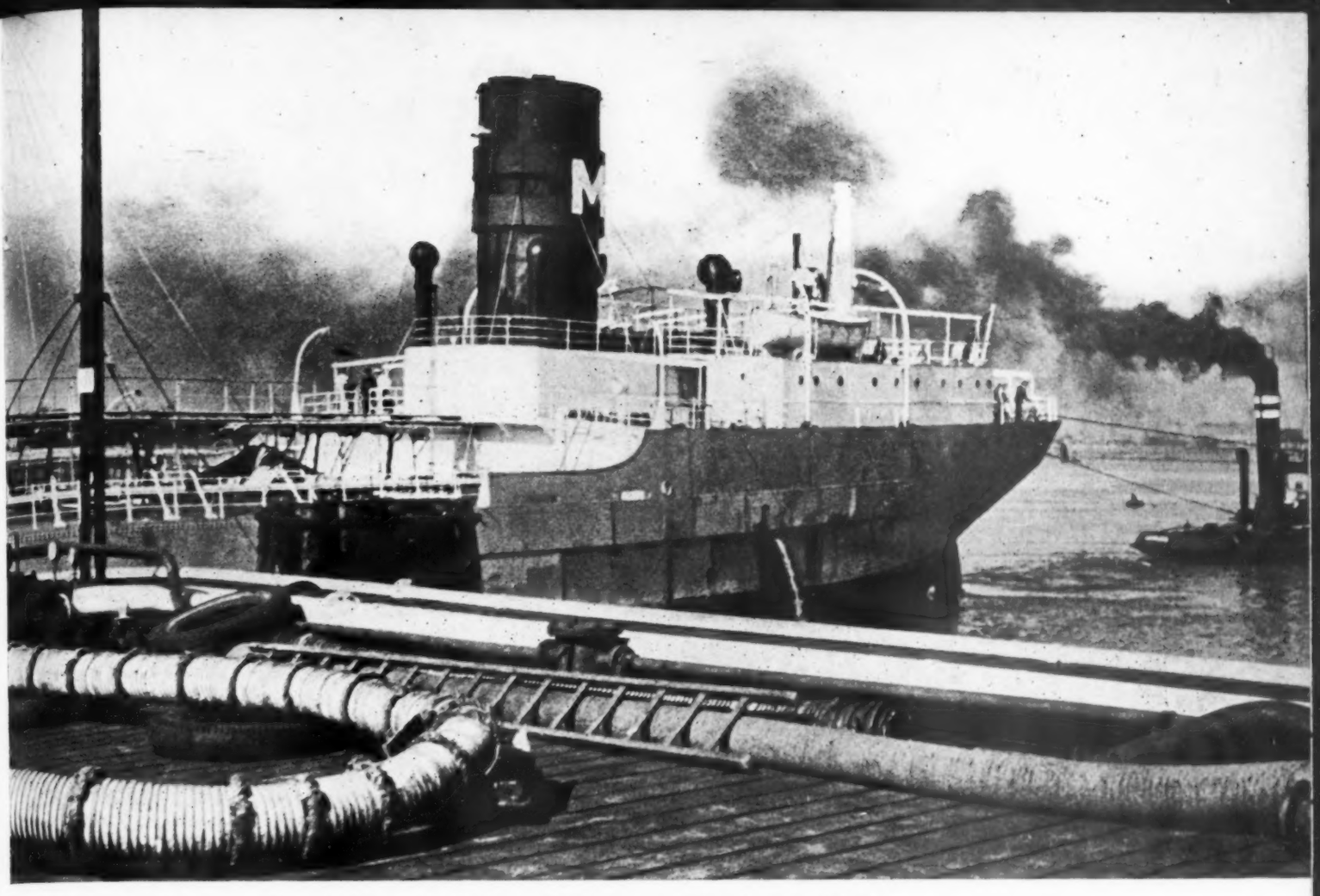
Now to consider the coastwise type of tanker, we have in general a vessel of characteristics similar to those of their deep-sea sisters, but of smaller size. The size is governed largely by the draft of water suitable for the ports of call. These vessels engage largely in deliveries from refineries to distributing stations of reasonably large storage capacity. Their cargoes therefore consist mainly of refined products, fuel oil and furnace oil, rather than crude oil. The coastwise tankers are capable of going to sea, but the off-shore requirements are limited, and they are mostly designed to engage not only in trade along the sea coast, but also in river and sound service, sometimes in canal service. Their steaming radius is apt to be limited. Many of this class of tankers are designed and built to the maximum dimensions and capacity for operation through the New York State Barge Canal, in conjunction with suitability, so far as these limits will permit, for lake, river, bay, as well as coastwise transportation.

An excellent example of this type is the REGENT of the Gulf Refining Co., built in 1934 at Sparrows Point. Her dimensions are 247 ft. by 40 ft. by 14.5 ft., with 12 ft. draft; displacement 2,700 tons; deadweight capacity, 2,120 tons; cargo capacity, 15,400 bbl.; bunker capacity, 40 tons; speed 9½ knots.

The REGENT has twin-screw Diesel drive. Each engine is a four-cycle, six-cylinder, single-acting, solid injection type, 14½ ins. by 22 ins., developing 425 b.h.p. at 280 r.p.m. There are three 50 k.w., D.C. generators, each driven by a four-cylinder, 7 ins. by 8½ ins. Diesel of 75 b.h.p.

In February, 1937, an order was placed by Cleveland Tankers, Inc., with the Pennsylvania Shipyards, Beaumont, Tex., for a Diesel tanker for Atlantic Coast, Barge Canal, and Great Lakes service. The dimensions are 258 ft. x 43 ft. x 16.5 ft.; cargo capacity to be 21,000 bbl. Propulsion will be twin-screw, by two 465 h.p. Winton engines, for a designed speed of 9¼ knots. Generators, compressors and pumps are also to be driven by Diesels.

Coming now to the smallest type of tankers, namely those built for harbor, river, bay and sound service, we find it difficult to generalize. Many of this class of tankers are



Rhenania-Ossag tanker loading at Hamburg, one of Europe's great oil ports.

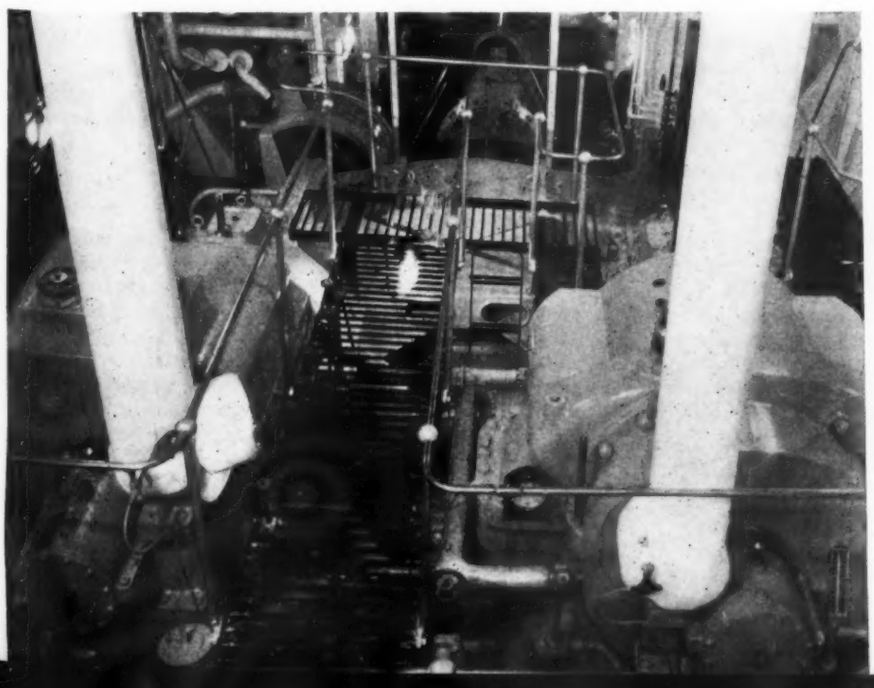
converted vessels of varying characteristics. In fact it was not until September, 1936, when the new U. S. Tanker Regulations became effective, that any rules existed to govern harbor tankers in general.

Perhaps the best examples of recent design for this class of vessels are the LUCY and the POLING BROS. NO. 14.

The LUCY was built in 1932 by Brewers Dry Dock Co., Staten Island, for the Reinauer Transportation Co. Her dimensions are 146 ft. by 26 ft. by 12 ft., with a cargo capacity of 230,000 gal. Propulsion is by a 400 h.p. Ingersoll-Rand Diesel engine. There are three rotary cargo pumps located forward, each driven by a 4-cylinder Diesel.

The POLING BROS. NO. 14 was built in 1936 by the John H. Mathis Co., Camden, N. J., for Chester A. Poling, Inc., of New York. Dimensions are 125 ft. by 27 ft. by 11 ft., draft 9 ft. Cargo capacity is 140,000 gal. of gasoline. Propulsion is by a 6-cylinder, 4-cycle, mechanical-injection direct-reversible Diesel engine of 275 b.h.p. at 275 r.p.m., giving a service speed of 9½ to 10 knots. Electric power under way is taken from a 3 k.w. shaft generator. When not under way, a 3 k.w. Diesel-driven auxiliary generator furnishes current. There is an oil-fired heating boiler in the engine room. Cargo pump is rotary, 760 g.p.m., in the pump room forward, driven by a Diesel in the adjoining pumping-engine room. The vessel discharges in about two hours.

Allis-Chalmers marine turbines in engine room of the R. P. Resor.



To summarize very briefly, the survey of recent tanker construction establishes the following indisputable facts:

The smaller tankers, coastwise, inland and harbor types, are entirely Diesel-driven.

In the large ocean-going tankers, steam propulsion predominates in the United States, although Diesel drive is favored abroad.

Certain tanker owners who had previously purchased Diesel-driven sea-going tankers in the United States, have returned to steam drive for U. S. construction.

Certain tanker owners, while building steam ocean tankers in the United States, have built Diesel tankers abroad.

The current construction of large Diesel tankers in this country is confined to one shipyard.

The reasons for these conditions provide subject matter for an exceedingly interesting and significant discussion which space prevents attempting at this time.

Omrosan Maru—latest 19-knot Japanese tanker for trans-Pacific service.

ECONOMICS OF TANKER SPEED

A RELATIVELY FEW years ago transportation of any form of cargoes in ships above ten knots was regarded as an economical waste and the carrying of oil at greater speeds considered least of all. It was the conversion of warships from coal to oil that made each nation look to its relative position in the world with the object of security as far as oil was a war or national necessity. As national need of oil gradually developed each nation increased its number, tonnage and speeds in tankers in a very modest way. It took the courage of the youngest maritime nation in the world to step out of the rut of slow-moving oil cargoes into high-speed tankers. Many reasons have been given as to the wisdom of this innovation and questions asked why the least experienced in shipping should make the bold stroke of jumping tanker speeds from 12 to 20 knots without the intervening steps considered so necessary by shipowners and shipbuilders of older and more conservative maritime countries.

Thirty years ago Japan scarcely knew or cared what a ship was, but necessity and national pride were the stimuli that made the nation send its brightest young men all over the world to study shipbuilding and management and at the same time secured the best possible talent to teach the youth at home. They set about building a mercantile marine in a thoroughly methodical way by adhering to basic principles, simultaneously developing on their own initiative radical changes by pioneering in oil tramp speeds and in oil tramp forms. Perhaps the end is not yet in sight but from an owner's or operator's point of view there is much to conjure with that may upset previous calculations and opinions.

There is no question that higher initial cost of the fast tanker liner is a major factor, but against this must be placed the greater number of barrels of oil delivered over a period of fifteen to twenty years or the life of the vessel. European countries have looked askance at this innovation and have not as yet attempted to copy or experiment with similar ships.

Is the liner tanker or the liner cargo carrier still to go further? Will it in the future be found necessary and economical to transport freight as fast as trans-Atlantic passengers travel today? With flying speeds forcing the tempo of transportation this would be only a relative and natural sequence.

It is not alone in speeds that the Japanese are leading, but in ship form and design. The year 1936 has demonstrated to shipowners that the whole question must be studied more closely as the building of faster ships has continued and is no mere flash in the pan as at first thought. Japan's influence is already felt as several 14-knot tankers are being built in European yards for private ownership.

Is the answer to all those radical changes so very definitely tied up with subsidies and naval requirements? In any event the tendencies of the moment are for increased speed and even conservative oil companies are working up their speeds, if only half a knot at a time. From a naval aspect perhaps the different governments will be compelled to leave all economic considerations out of the question and build all auxiliaries to the fleet, including tankers, to keep pace with the fastest vessel. As an auxiliary naval fleet of high-speed tankers would be prohibitive and useless in times of peace it behoves any government to consider seriously the tanker or storage afloat in a similar position to tank storage ashore, as carriage of oil is just as essential if not more so to security of a nation as storage capacity ashore. Tankage ashore is useless if the conveyors are not capable of maintaining a constant stream of oil to replenish depleted tanks. If security of a nation requires high-speed oil-carrying vessels for this purpose, the need is just as great for any other non-producing country. Direct subsidies should be money well invested where countries produce no oil of their own and are dependent entirely on transportation for fuel for the navy and a mechanized army.

It is a well-known fact that Japan owns but a very meagre portion of the sources of petroleum supply: several oilfields dotted along the north coast of Honshu represent about the whole of her natural resources; in consequence she has to import more than 90 percent of her annual consumption, which amounts to approximately 3,000,000 tons, excluding oil purchased for use of her navy. Consumption of petroleum in Japan is increasing at a very rapid rate, the fishing fleet alone consuming around 800,000 tons during last year.

It is only natural that Japan should look to her own requirements in oil and means for its transportation. As it gradually dawned upon them how vital it was for national security to own a fleet of tankers they were confronted with the problem of how best to approach this difficulty in order to solve the question both efficiently and economically.

There were three possible courses open for them to consider and pursue: they could build as many vessels as they required along

the lines of the conventional tanker; or fewer big tankers of larger deadweight carrying capacity; or, alternatively, a smaller number of fast tankers of more moderate deadweight. They decided to tackle the problem by the third method, a smaller number of tankers, of conservative tonnage, with much higher speeds.

We must recognise that in various ways the trans-Pacific oil route possesses for Japan a singular geographical advantage from the point of view of tanker operation. Yokohama, Japan's oil terminal—where more than 70 percent of the total oil for Japan is landed—is also a premier silk port. Raw silk ranks first among Japan's staple exports and its biggest customer is the United States. Export centres are Yokohama and Kobe, but by far the greater proportion is shipped through Yokohama. Silk moving from Japan to U. S. A. averages about 600,000 bales yearly. With the advent of very fast tankships on the Orient-New York run a large part of this valuable cargo has been diverted via the Panama Canal route, and there is also a considerable amount of silk shipped by tanker through Pacific coast ports in transit to New York by express silk trains.

Tankers are usually equipped with dry cargo holds, capacities of which range from 500 tons to 2,000 tons, which are suitable for carriage of the highest class of cargoes. Raw silk is packed in bales of about 6½ cubic feet each weighing about 130 lbs., making it one of the most convenient cargoes for sea-borne freight. As raw silk stows five to six bales to the ton of 40 cubic feet, the above holds can accommodate from 2,500 to 10,000 bales of silk.

By virtue of a comparatively high freight rate for this particular cargo these cargo spaces, though limited, can be utilized for carrying silk and earn an appreciable amount on outward passage, which, in the case of ordinary tankers, usually has to be undertaken in ballast.

There are various kinds of bulk oils—vegetable and fish—which are characteristic products of the Orient. Among those, Japan produces rape, tung, perilla, and soya bean oil and several kinds of fish oils. It is a usual practice on the part of shipping companies to accommodate these oils in deep tanks specially built or partitioned off, their capacities ranging from 150 tons to 300 tons, which meets requirements in quantities the markets can absorb.

Although export of these oils is more intermittent and uncertain than silk, fairly good freights can be expected; hence the necessity of fitting special small tanks for this purpose.

The principal object of the tanker is to carry petroleum in bulk in the safest and most economical way, but it must also be kept in mind that more oil can be carried by fast tankers during a specified period because of a quicker turn-round, and fewer tankers are required to carry this specific amount if carried at a high rate of speed.

Distance from one of the Californian oil ports, say, Los Angeles Harbor to Yokohama is 4,840 nautical miles. A tanker of moderate speed, outward in ballast at 12 knots and homeward at 9 knots when full, takes 17 days going out and 25 days coming back, with three days in ports, thus requiring 48 days to complete a single voyage. A fast tankship of the NIPPON MARU type, running out light at 17½ knots and returning at 16 knots fully laden, taking only 11 days going out and 13 days coming home, with three days in ports, requires only 28 days to finish one complete voyage.

Supposing both ships are working 11 months out of any one year, the number of voyages performed by the respective type of tankers will be 6.87 and 11.43 per annum. Let us make this for simplicity seven and eleven voyages, respectively.

Assuming that these vessels can carry 12,000 tons each, excluding bunkers and stores, the total tonnage of oil to be transported by each of them will be 84,000 tons and 132,000 tons respectively. In other words, there is a difference in the annual carrying capacity of about 48,000 tons. Suppose that 3,000,000 tons, the actual requirements of Japan per annum, be catered for by tankers of either of these classes, the number of tankers required would be 36 to 23 ships respectively. This is more or less theoretical, but will serve to give a general idea of speed in relation to the number of ships required.

Bearing this in mind, let us now examine the expenditures on this basis of comparison. With the decision to adopt single screw propulsion, and taking into consideration the higher horse power, there is practically no change in number of crew—as in most cases only one or two extra hands are added in excess of an ordinary tanker's complement. Extra expenditure for equipment and stores, including lubricating oil and spare parts, will be 30 percent of that for slower ships.

The biggest operating item is the fuel bill. The NIPPON MARU with her 9,000 b.h.p. machinery burns approximately 25 tons daily compared to 14 tons for the older type tankers. Roughly, the annual fuel consumption will be 6,600 tons, compared to 4,116 tons.

There is not much difference in port charges; in Japan and United States tonnage dues are payable either per call, or per annum, tankers usually pay a tax per annum, so the increase in expenses under this heading, if any, will be negligible.

COMPARATIVE EXPENDITURES

	Fast Tanker	Ordinary Tanker
Pay roll	£2,900	£2,820
Victuals	850	810
Running stores	1,000	600
Equipment, etc.	300	280
Fuel bill	9,900	7,174
Repairs	1,200	900
Port charges	520	400
	£16,670	£12,984
Interest charges (including insurance and ordinary upkeep and repairs)	15,000	11,400
Total	£31,670	£24,384

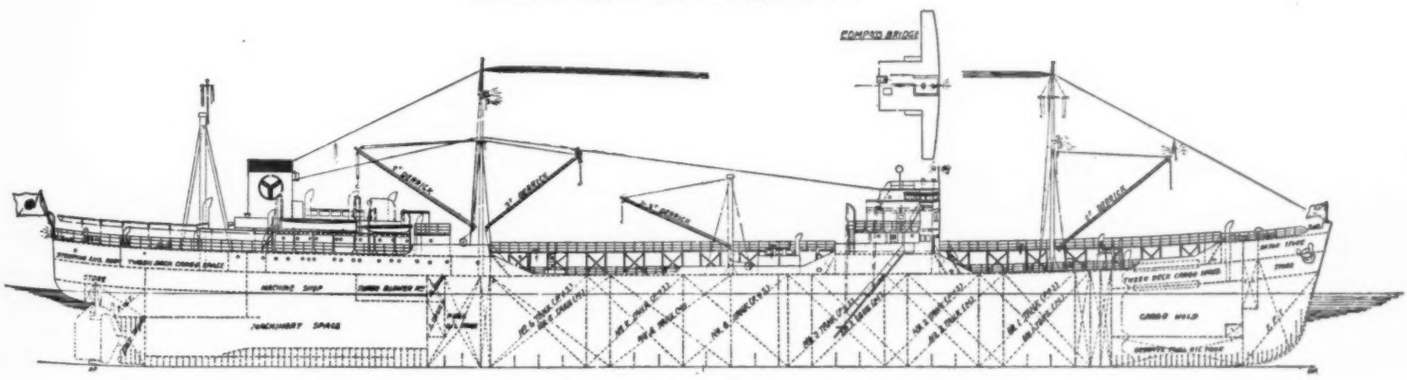
Now the question is whether or not the extra 48,000 tons of oil carried and the earnings from silk, and special oils can absorb the difference of £7,000. It is only necessary to mention that the freight on silk at the current rate of exchange is 17-odd shillings per bale and the rate on fish oils from California to Japan fluctuates between 10 and 17 shillings per ton.

No consideration has been given to the initial cost of the relative ships as those vary largely according to where they are built, whether they are classified, also upon the inclusion of special tanks and equipment for fish oils, as in the case of those highly specialized ships for a particular trade.

It is only a relatively few years ago that Japan presented a very poor figure in the tanker ownership world. Three tankers of the SAN LOUIS MARU class, owned by Mitsubishi, represented practically the entire tanker fleet, apart from about a dozen tankers maintained by the Imperial Japanese Navy for its own use.

First to arouse attention was the TEIYO MARU when she established a record for tankers crossing the Pacific at an average speed of 17.53 knots in May, 1931. This achievement caused considerable comment and no little criticism, as it was a radical departure from all preconceived ideas of the

General arrangement of the Nippon Maru.



old tanker doing 200 to 250 miles per day.

TEIYO MARU was built and engined by the Yokohama Dockyard Co., on account of Nippon Tanker Kisen Kaisha, who were the first to embark upon an aggressive policy with regard to transportation of oil. This tanker carries 12,200 tons deadweight and her propelling installation consists of two M.A.N. engines rated altogether at 7,200 b.h.p. at 125 r.p.m., enabling her to maintain 15 knots at sea fully laden. Singularly enough, she is the only Japanese tanker of the latest type which has adopted twin screw propulsion.

Shortly afterwards came the FUJISAN MARU, which attained 18.8 knots on her trial, and then the TOA MARU and KYOKUTO MARU, which reached 19.25 knots, followed immediately by TATEKAWA MARU class, which attained the striking speed of 20.5 knots in loaded condition.

It will suffice for us to review the NIPPON MARU, among the latest of them all, in order to obtain a rough idea of the lines along which Japanese tankers are being developed. Her owners are the Yamashita Kisen Kaisha and she was built and engined by Kawasaki Dockyard Co., Kobe. It is worthy of mention that she was completed during June, 1936, within eight months of her keel being laid.

She is 499 ft. 8 ins. in length, 64 ft. 9 ins. in breadth and 37 ft. in depth and is capable of carrying 13,340 tons on 29 ft. 5 ins. draft. Her propelling plant consists of one set of 9,000 b.h.p. M.A.N. type double-acting two-stroke airless-injection Diesel engines. The vessel is of three-island type, having a raked stem and cruiser stern, fitted with a contra-balanced rudder and has one continuous steel deck. There are two longitudinal bulkheads, which extend to the upper or shelter deck and a number of transverse bulkheads, staggered to form six cargo oil tanks port, six starboard, and five in the centre, making a total of 17 tanks.

Electric welding has been extensively employed in construction of longitudinal and transverse bulkheads, engine room casing, cabin bulkheads, superstructure, decks, seatings for generator and auxiliary machines, winches and windlass seats, masts, booms, posts and oil delivery pipes.

The main pump room is arranged amidships and there are four cargo oil pumps, each with a capacity of 265 tons per hour. There is also a vegetable oil pump in a forward pump room to facilitate discharge of the special oil.

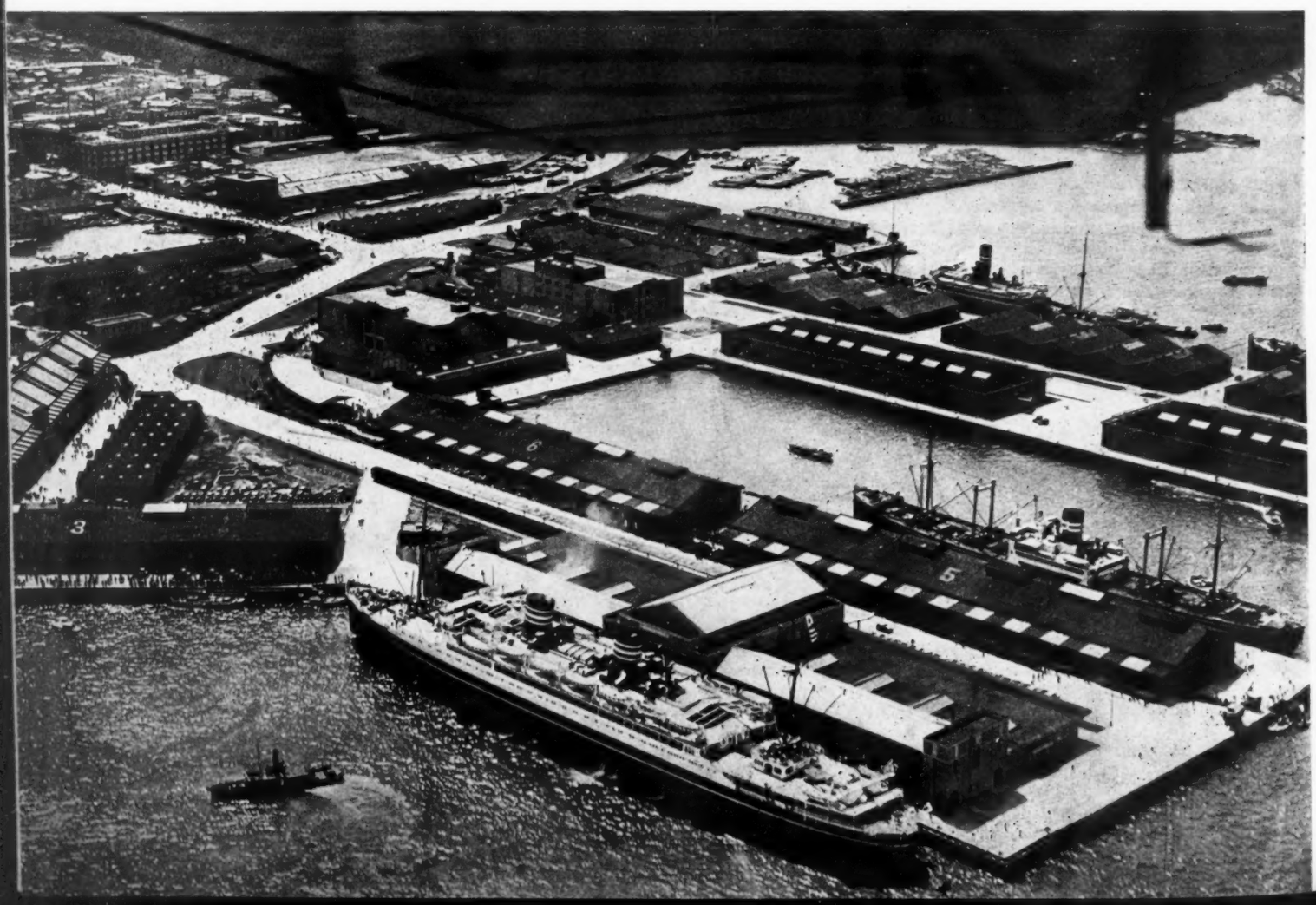
Two wing tanks are situated in the forward part of both starboard and port sections for carriage of special oils, and another feature is the exceptionally large general cargo hold suitable for carriage of raw silk and other high class cargo.

Many reasons have been ascribed as to why high-speed tankers are being built by Japanese owners. No one will deny that a high-speed mercantile marine, especially tankers, would be of inestimable value as an auxiliary unit to naval or military operations in case of war, but to this must be added considerations of economic and scientific nature. Contrary to general belief no special tanker subsidy initially existed in Japan and practically three-fourths of those new tankers were built without any government assistance. There is a shipbuilding subsidy commonly known as the "scrap and build scheme," but only four tankers so far have been built with this assistance.

This scrap and build scheme was first introduced in 1932, when there was much discussion over the redundancy of world tonnage, and Japan took the initiative, with a view to reducing her tonnage and thus assisting the world shipping rationalization scheme; the amount of the subsidy was 45 yen (56 shillings) maximum per ton. The object of the scheme was scrapping rather than building by providing for breaking-up of 400,000 tons of obsolete shipping and the building of 200,000 tons new ships over a period of three years.

Since this time the Japanese Government has put forward a most ambitious programme of legislation for expanding their national mercantile marine. Its purpose is to increase the national tonnage of a little over 4,000,000 tons to twice this amount by granting government aid in direct subsidies and loans at a low rate of interest on all new construction. Included are high class passenger ships of over 25 knots, tankers at 20 knots and cargo carriers at similar speeds. This is one of the most far reaching projects of its kind ever launched by any nation in times of peace.

Ocean quay at Yokohama silk terminal, now a regular port of call for oil tankers.



WELDING GAINS FAVOR IN TANKER CONSTRUCTION

By K. A. Ringdahl, Civ. Eng.

AT PRESENT the shipbuilder is straddling the question of riveting or welding. He senses changing conditions but dares not proceed too rapidly in converting his yard from a very efficient riveting organisation to an equally efficient welding plant. All the same it behoves him to take cognizance of the current trend. How is the tank ship of the future going to be built? If welding becomes universally adopted current methods of assembly will have to be discarded and planning of construction work must of necessity be entirely different from present riveting procedure. Then, instead of having the gradually assembled multitude of relatively small units drawn together by bolts and riveted into a homogeneous mass, he will be faced with the problem of connecting those units without, if possible, the temporary or preliminary process of bolting.

This calls for a maximum of "down" or "flat" welding and means that much larger units will be assembled on the ground where adequate apparatus will handle to the best advantage. Large portions of the stem and stern, and whole bulkheads with a part of the shell attached, may be completed before being placed for general grouping. As the shell is the greatest problem it must necessarily be given the most consideration. By the whole problem of the continuity of strength being altered and the shell now becoming virtually one continuous plate, it may add to the ease and economy of construction, if the shell is plated vertically around the forward and after ends and for a limited distance at all transverse bulkheads, the ends and bulkheads to be linked up with longitudinal plating. It may be no longer necessary to fit bounding bars at bulkheads, decks, or tank tops, but the plates may be welded direct to the shell. Angles as we know them today may be entirely discarded even for the frames, and webs or upright flanges only welded to the shell direct. Many advantages may be gained by primarily erecting only the heavier structural units, to take the form of the ship, welding the shell from the inside and adding the frames and stringers later.

Those and many other problems will have to be solved along with the ever present one of plates being distorted and warped by local heating. However, the solution to all those problems will gradually be reached and the all-welded tanker of any size or speed will become more and more a reality.

When the well-known Swedish Engineer, O. Kjellberg, started his welding business at the beginning of this century, ship repairs formed the bulk of the work. This type of work was also the main business of most of the other welding companies which came into being between 1910 and 1920. The volume of repair work became considerable, but it was some time before arc welding was used as a means of construction on new tonnage.

During the war several all-welded vessels were built, a few barges in Great Britain and a tugboat in the United States. Shortly after the end of the war a number of small vessels and barges were built in Sweden, Great Britain, Japan, France and U. S. A., by this process. One of the larger vessels from this date is the British built FULLAGAR. This ship had a cargo carrying capacity of about 500 tons deadweight and was built 1919–20. An all-welded ferry for 2,500 passengers was built in Japan about 1920. Somewhat later a 900-ton vessel was built by La Societe de Chantiers de Normandie, in Rouen.

Although the above vessels were welded, construction was mostly on the same principle as with riveting, the vessels having lap joints and the faying flange on frames and deck beams. Design and yard practice have benefited considerably from welded or partly welded warships built later on by various navies, especially the German and American.

The first warship to be welded to a larger extent was the German cruiser EMDEN and it is curious to note that it was due to the French occupation of the Ruhr that welding was taken up; because of Z bars not being obtainable the ordinary angle bars had to be welded together. One of the first welded tankers to be built was a 145-ft. ship, constructed by the German Navy for its own use. Of special interest in this tanker was the "egg box" construction of the floors and longitudinals. Another welded tanker built about the same time was the American CAROLINIAN, which had dovetail joints—a rather complicated and unnecessary type of connection.

The above ships were built in 1929–1931 and were followed by a number of welded tankers and tank barges, among which may be mentioned the motor tanker BRANAREN for the Swedish Navy, built in 1932 by Kockums, with a length of 150 ft. She was welded to the extent of 70 percent of her construction. When the BRANAREN was built every second frame was riveted to the shell and every other welded, and this method was used to get the erectors accustomed to welded construction.

A shipyard with considerable experience in welded tankers is Swan, Hunter, and Wigham Richardson, Ltd., who have to a great extent furthered the design and building of welded tankers. One of the tankers built in this yard is the PETER G. CAMPBELL for service on the Great Lakes, originally designed as an oil-carrying barge but later fitted with propelling machinery. Another all-welded tanker built by them is the Norwegian owned MOIRA, 2,240 tons deadweight, which is one of the largest all-welded tankers completed to date. The largest welded tanker in service is the 2,461-ton deadweight TRANSOIL, built in America.

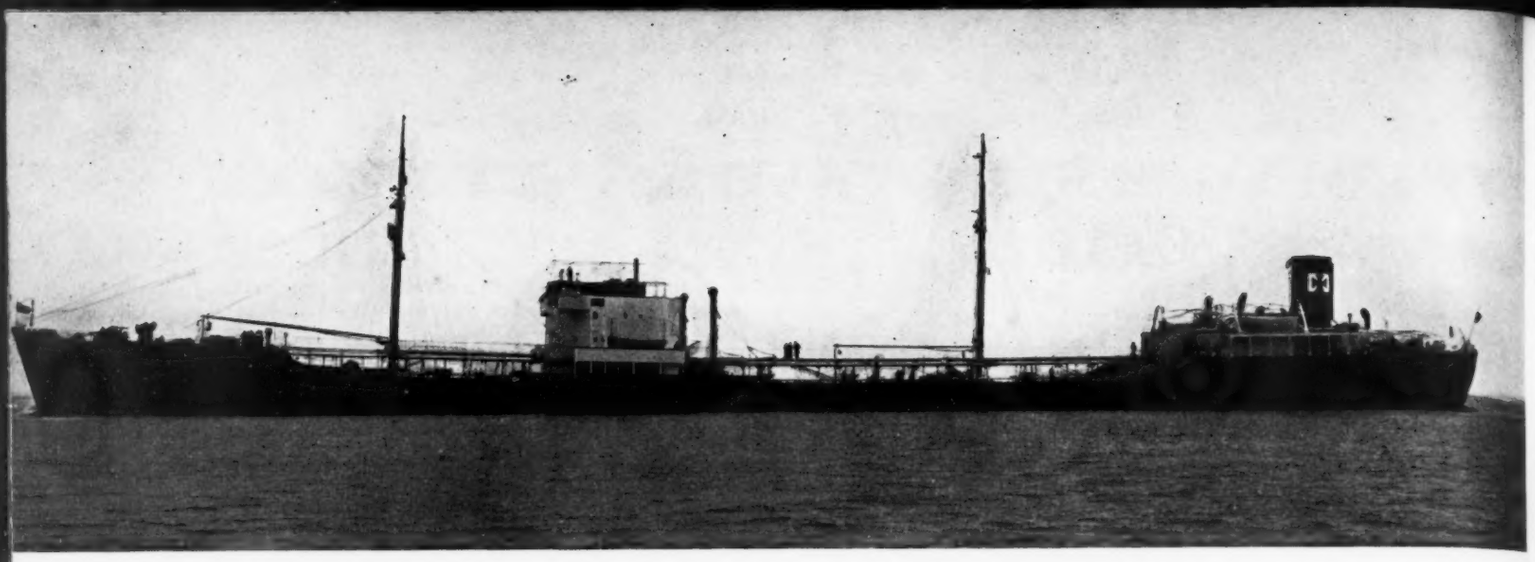
Among the welded ships now under construction mention should be made of the tankers now being built at the Kockums and other Swedish yards. These ships are practically all-welded except for the seams in the shell plating. Sun Shipbuilding and Dry Dock Company, of U. S. A., is also building a large tanker of 521 feet length, having all main structural units welded. Those ships are mentioned to illustrate the development of welding in tankers.

How does welding of ships benefit the tanker owner? On the credit side we have:

1) Lighter and stronger hulls and a larger carrying capacity for the same dimensions.
2) Definite oil tightness.
3) Smoother underwater surface, which is a contributory factor towards reducing propulsion power for a given speed.
4) Easier maintenance and less corrosion. Easier to clean if changing over from dirty to clean cargos.

On the debit side we find:

1) Welded steel work is often more expensive per ton built-in material than riveted steel work.
2) Difficulty of finding and training new welders to ensure good workmanship.
3) Contraction and warping due to the welding heat.
4) Lack of suitable shapes or sections to give the most economical results in welding.
5) Closer inspection necessary for welding than riveting and consequently more costly.
6) Climatic conditions.



The Ferncastle is another example of modern European tankship design.

In considering the above points we find that the saving of weight due to welding a standard type of ship can roughly be taken as 10 to 30 percent, compared with a corresponding riveted vessel. To reach these figures it is necessary that the ship be satisfactorily designed and full use made of all possibilities for welding. Naturally some structural members are more suited to welding than others and maximum economical results may often be found by making the ship partly welded and partly riveted. So far, no all-welded merchant ship has been built of over 3,500 tons deadweight.

Saving in the hull weights does not necessarily mean that a welded ship for a given cargo capacity would be cheaper than a riveted vessel of the same capacity, the cost per ton of welded built-in material may run as much as 25 percent higher. This percentage will vary considerably with the size of the ship, if it is classified or not, and also the country in which it is built. For smaller ships and barges there are many cases where the cost per ton of welded built-in material is as low as the cost per ton of built-in material when riveted. Saving in shell weights could be considerably increased if classification societies permitted a thinner shell, corresponding to the higher efficiency of welded joints as compared with riveting.

The most complicated part to erect and weld is the vertical shell and extremely curved or heavily worked plates. When it comes to welding shell plating there are many reasons for proceeding slowly until better erection methods have been found.

The welded hull can claim to be considerably stronger, as proved by actual experience. The previously mentioned FULLAGAR ran aground and her bottom was badly buckled; all the welded joints held, riveted seams would have opened up under similar conditions. The bow of a German destroyer in collision was welded and partly riveted; the riveted joints were torn apart, the welded joints remained intact.

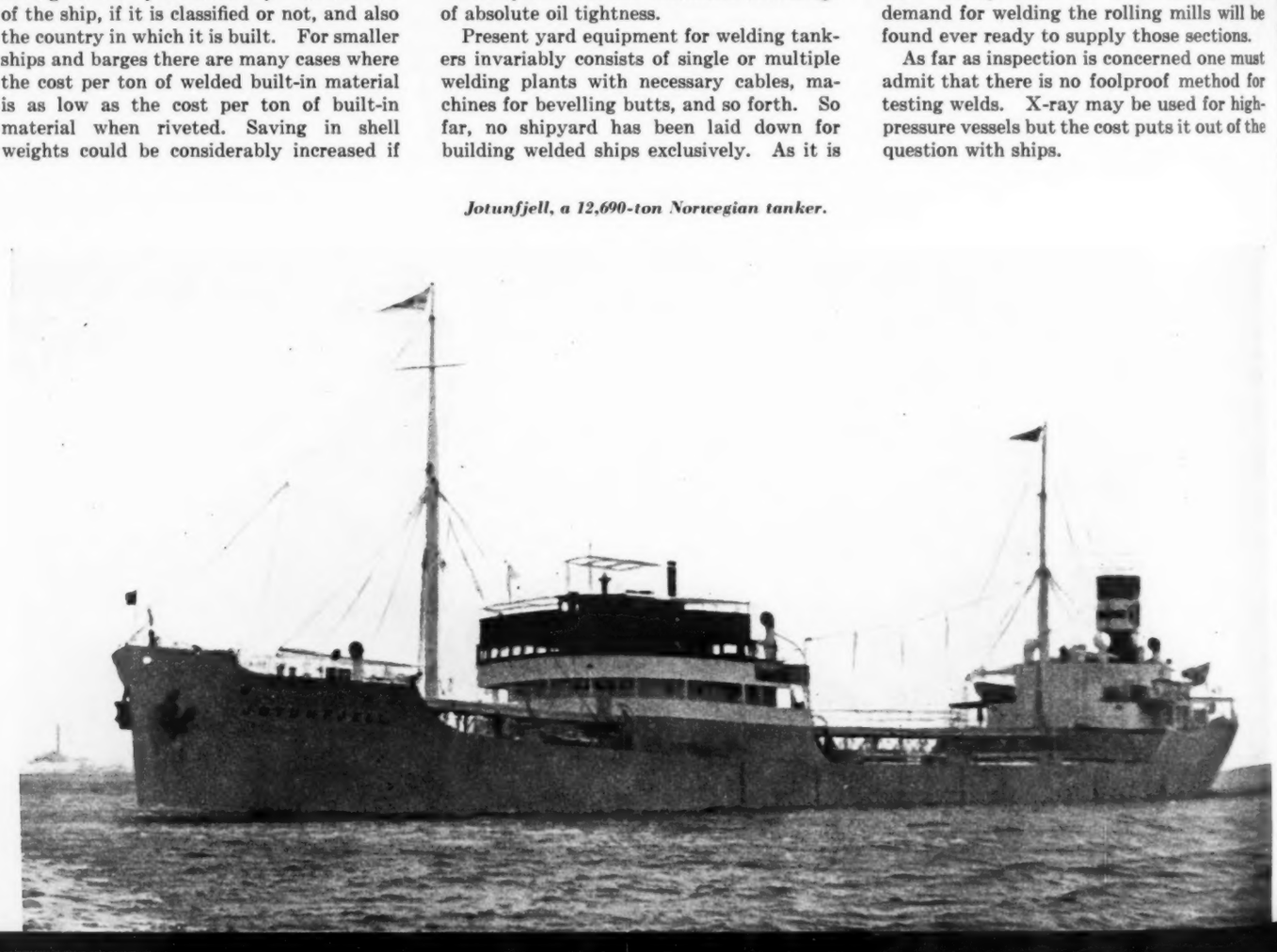
A good welded joint is superior to a good riveted joint with the additional advantage of absolute oil tightness.

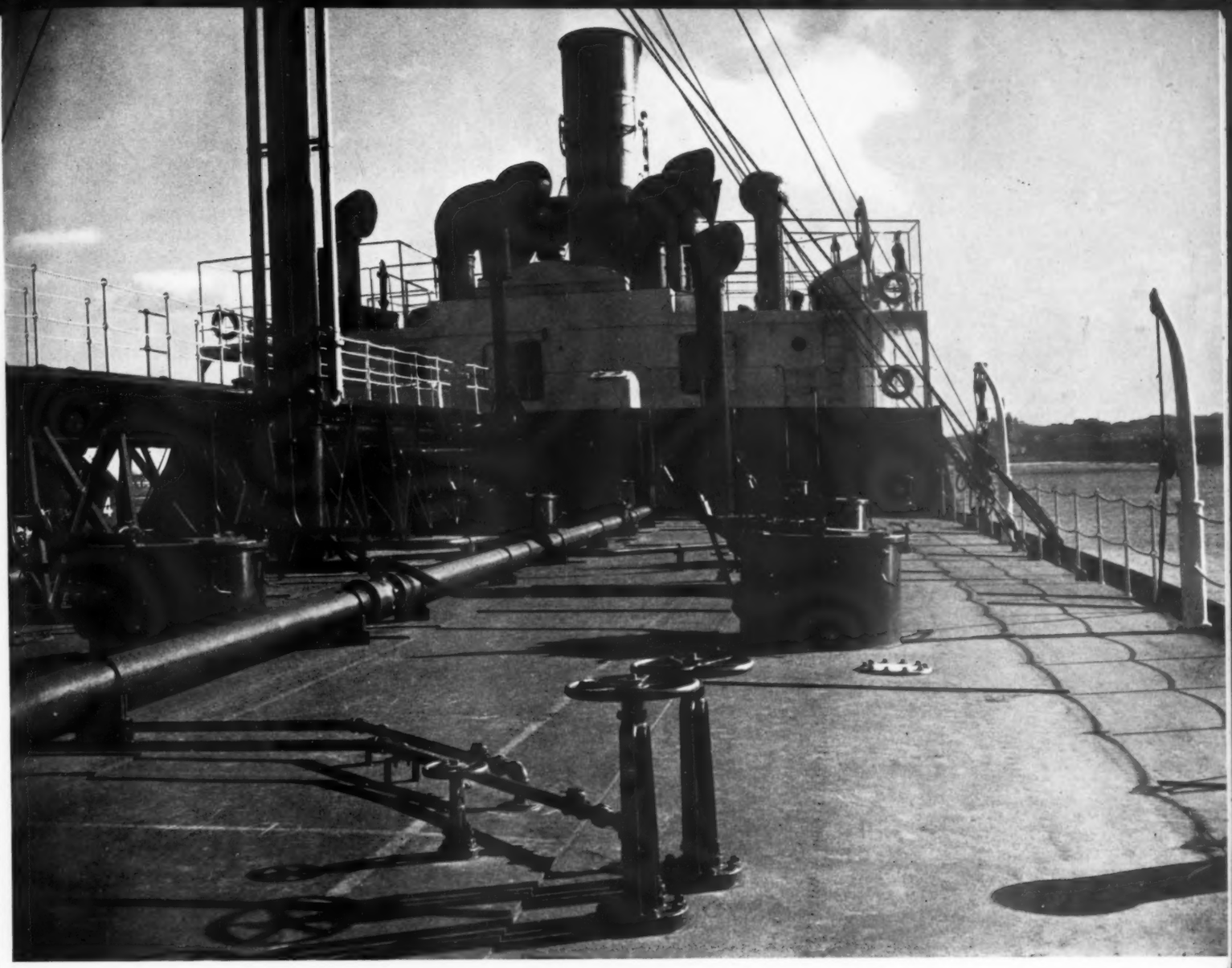
Present yard equipment for welding tankers invariably consists of single or multiple welding plants with necessary cables, machines for bevelling butts, and so forth. So far, no shipyard has been laid down for building welded ships exclusively. As it is much more satisfactory to fabricate large sections before fitting to the ship, crane and transport facilities will have to be increased to meet this condition. Contraction and warping of plates gave considerable trouble in the early days and still has to be reckoned with; however, shipbuilders, by using the right sequence in construction and keeping the members free as long as possible, now have this problem partially solved. In no other branch of engineering have such large plate surfaces to be welded together as in shipbuilding. On the other hand, being smaller units, there is considerably more flexibility in a vessel.

All commercial shapes or sections now on the market have been designed for riveting. What is especially needed is a bigger variety of T bars with a thin web and a heavier flange. Such sections will now be rolled as the necessity arises and with the increased demand for welding the rolling mills will be found ever ready to supply those sections.

As far as inspection is concerned one must admit that there is no foolproof method for testing welds. X-ray may be used for high-pressure vessels but the cost puts it out of the question with ships.

Jotunfjell, a 12,690-ton Norwegian tanker.





Highlights and shadows on a tanker deck.

At present most of the classification societies approve a certain brand of electrode after thorough tests under shipyard conditions, and samples are regularly taken from the manufacturers' storeroom for periodic tests.

A good electrode is not all that is sufficient for good welding; reasonably skilled welders, thorough supervision during the welding, and careful inspection afterwards, are the only safeguards. Climatic conditions affect welding materially; extreme cold or dampness must be taken into consideration. If the necessary precautions are taken outside welding can be carried on throughout the year and during the most severe winters.

Welding will gain ground slowly in shipyards because this form of fabrication is one of the most revolutionary technical achievements of the last thirty years.

Welding affects the design of various members of the ship. Plates can be joined either by butt or lap joints, the butt joint is mostly used because it gives the greatest saving of weight and is the most efficient in strength. The lap joint, even if considerably less in size than that used for riveting, facilitates erection and in addition does not require the accuracy in fitting called for in butt welding.

Stiffening members—transverse or longitudinal framing, girders, deck beams, and bulkhead stiffeners—are usually fastened to the plating by intermittent welding. Saving in weight here is due to the fact that faying flanges are omitted, and for heavy built up girders there is a deduction for rivets. In addition the welding does not decrease the strength of the plating or bars as is the case with riveting. Other elements of the ship, such as engine seatings, benefit most in weight from welding and on small or auxiliary seatings saving runs up to 50 percent.

Two welding methods of construction are worth mentioning. First, the "Truss" system. The shell, without flooring or framing except in the engine room, is supported by three systems of parallel angle bars, equally spaced, running longitudinally, transversally and vertically, thus creating a "cubic" frame work. This gives a very rigid structure easily welded, especially as the shell and deckplating will only be welded to the framework at local spots. The complete sealing of the contact points between the framing and the plating will be an advantage in the prevention of corrosion.

The same applies to the "F.F.F." (Free Flow Frame) system. Here the framing proper is not in contact with the plating, the outer side being a couple of inches from the plating to which it is connected by T lugs lapped on to the frames. In addition to advantages from cleaning and corrosion, the framing will be better utilized and less welding heat will attack the plating when connecting the frame.

Further developments in structural arrangement of tankers can be expected not alone on the hull but also on Diesel motor frames and steam boilers.

Tankship owners will not order all-welded tankers just because they are welded; indications are that the all-welded tankers and the partially-welded tankers are now on a competitive basis with riveted tankers. In a few years many of the present difficulties will be eliminated and an ever increasing number of welded tankers will be put into commission, as the confidence of owners and their technical advisers increases.

Foreign Oil Legion

HARRY F. SINCLAIR was elected chairman of the board of the reorganized Richfield Oil Corporation at the first director's meeting, held on March 10th. The new company is the result of combining the old Richfield organization with the Rio Grande Oil Company. William C. McDuffie was elected chairman of the executive committee, and Charles S. Jones becomes the new company's first president. Mr. Jones has been connected with Rio Grande Oil since 1916 and became its president in 1932 when it was purchased by Consolidated Oil Corporation. He has served two terms as president of the California Oil and Gas Association and was general chairman of the American Petroleum Institute convention at Los Angeles in 1935.

When Mr. McDuffie resigned from the Shell organization in 1928, after seven years' service with the company, he was general manager of world-wide production for the Royal Dutch-Shell group, working out of The Hague. He left Shell to take the presidency of Pacific Western Oil Company, which was then being formed in Los Angeles. January, 1931, found him again taking over new duties, this time as receiver for Richfield Oil, which now has led to his election as chairman of the executive committee of the new company.

JOHN W. LEONARD, president of Leonard Petroleum Company, who left New York early in March for Colombia to look over properties held by Leonard Oil Development, returned to New York March 26th on the S.S. NEW YORK of the Hamburg-American Line. On his trip south Mr. Leonard went as far as Panama by boat, continuing on down to Bogota by plane via Medellin. Leaving Bogota three days later, he set out by plane and auto for Santa Maria on the Sogamoso River, there to inspect the Marta properties, jointly controlled by the South American Oil Co. and the Sociedad Colombiana de Petroleos, S.A., and the adjoining Las Monas properties, controlled by Leonard Oil Development. Mr. Leonard was particularly interested in Socony's new well (on Luciano Restrepo's former concession) which was down to 300 ft. and is expected to be a producer. It is located about 1,000 ft. from well No. 6 on the adjoining property controlled by Leonard Oil Development. Mr. Luciano Restrepo arrived in New York from Bogota and Medellin on the same boat with Mr. Leonard.

M. R. Bridgeman

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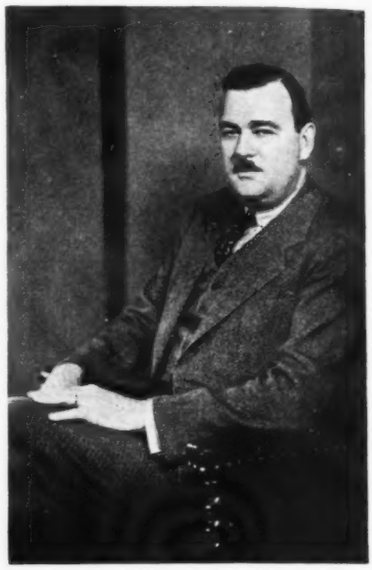
W. D. Brown

M. R. BRIDGEMAN, representative in the U.S.A., of the Anglo-Iranian Oil Company, Ltd., for the past three years, has returned to the head office at London. He sailed from New York April 7 on the QUEEN MARY. W. D. Brown, who has been on the London staff, has now taken over Mr. Bridgeman's duties in New York.

ANDREW AGNEW, C.B.E., director of the Anglo-Saxon Petroleum Company Ltd., and Eagle Oil & Shipping Company Ltd., and managing director of Shell Transport and Trading Company, has been elected a member of the General Committee of Lloyd's Register, in succession to Viscount Bearsted, M.C.

TOM BELL, one of the first rotary men in California, left New York on the QUEEN MARY March 24th en route to Portuguese East Africa, where he will be in charge of drilling for Inyaminga Petroleum (1934) Ltd. Mr. Bell flew east from Los Angeles via sleeper plane and spent several days in New York before sailing. When he arrives in England, he again will take to the air, flying from Croydon to Salisbury, Union of South Africa, via Imperial Airways—a total of seven days in the air. From Salisbury he will travel by rail to Beira, in Mozambique, Portuguese East Africa; thence by river-boat to Inhaminga, scene of the drilling operations, where he is due about April 10th. In addition to being one of the first rotary drilling men in California, Tom Bell took some of the first rotaries to Roumania in 1914, and was instrumental in introducing rotary drills in that country.



Charles S. Jones

H. M. HERRON, president of California Texas Oil Company, returned to New York early in March from a trip to Bahrein, Iraq and other points in the Near East. "From the point of its world relationships", says Mr. Herron, "the problem of the oil industry in the immediate future is to find the supplies that are being demanded in ever increasing volume and the Near East is one of the hopeful sources of supply." James A. Moffett, chairman of the board of California Texas, is on a three-months' tour of inspection that will carry him to Australia and the Far East.

WORLD OIL PRODUCTION—Official Figures

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified—Table revised monthly

(Figures in U. S. Barrels—Convension ratio 7 bbl. = 1 ton)

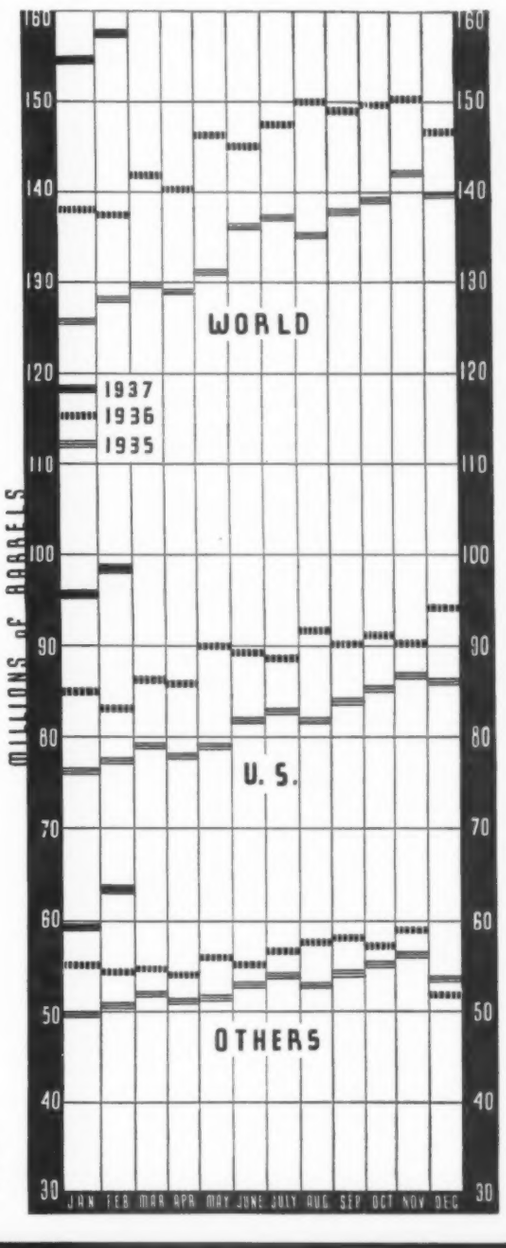
Country	March 1936	April 1936	May 1936	June 1936	July 1936	August 1936	September 1936	October 1936	November 1936	December 1936	January 1937	Provisional Figures February 1937
United States	90,568,000	90,479,000	93,739,000	90,185,000	92,078,000	95,090,000	90,972,000	95,795,000	91,018,000	97,652,000	98,567,000	91,770,000
Russia	16,344,300	15,589,000	16,454,200	15,955,100	16,231,600	15,737,500	14,936,600	16,118,900	16,700,000 [1]	16,400,000 [1]	16,100,000 [1]	14,600,000
Venezuela	13,432,671	13,442,870	13,732,933	12,486,600	14,566,510	14,632,737	14,626,073	13,888,287	14,307,650	8,452,626	9,888,298	13,583,024
Roumania	5,209,000	5,226,000	5,568,000	5,563,000	5,606,000	5,585,000	5,254,000	5,224,000	4,982,000	5,050,000	4,768,000	4,217,000
Iran [2]	4,641,000	4,312,000	5,376,000	5,061,000	4,872,000	5,117,000	4,487,000	4,704,000	4,620,000	4,963,441 [1]	4,849,919 [1]	4,380,572
Netherland India	3,670,877	3,532,375	3,721,613	3,549,417	3,725,491	3,715,887	3,731,973	4,059,426	4,139,954	4,190,578	4,009,355	3,768,975
Mexico	3,542,088	2,997,883	3,235,255	3,167,300	3,179,614	3,773,503	3,768,855	3,235,224	3,204,007	4,259,733	4,233,635	3,922,999
Iraq	2,515,345	2,048,053	2,467,136	2,473,660	2,440,669	2,479,428	1,881,782	2,097,564	2,214,954	2,207,954	2,476,698	2,240,119
Colombia [3]	1,619,620	1,427,193	1,598,544	1,529,901	1,585,345	1,553,606	1,575,273	1,600,288	1,537,683	1,641,636	1,668,490	1,617,441
Peru [4]	1,351,810	1,403,626	1,500,485	1,452,306	1,524,303	1,527,072	1,478,482	1,507,433	1,445,605	1,492,023	1,448,545	1,321,989
Argentina	1,366,691	1,260,277	1,231,354	1,140,080	1,286,536	1,293,283	1,323,730	1,306,784	1,310,000 [1]	1,472,748 [1]	1,317,252 [1]	1,189,776
Trinidad	1,081,191	1,026,423	1,066,728	1,078,186	1,121,583	1,108,969	1,126,420	1,179,611	1,154,093	1,231,365	1,263,456	1,157,408
British India	791,162	790,376	827,762	778,947	817,364	815,415	791,217	730,860	778,617	809,218	788,299 [1]	729,988
Poland	338,800	323,400	331,100	287,000	294,000	301,000	294,000	301,000	294,000	301,000	295,400	294,000
Brunei	257,250	270,900	225,890	206,780	266,700	275,310	257,040	294,070	294,560	322,210	354,480	327,600
Germany	274,393	246,519	244,552	256,613	272,699	257,859	255,556	277,158	265,650	279,545	265,531	233,366
Japan	196,569	194,167	203,071	198,387	206,284	221,139	207,260	200,528	202,385	212,326	219,410	212,631
Ecuador	162,125	159,666	163,855	156,703	163,714	160,914	158,857	168,892	163,870	175,918	180,058	160,675
Sarawak	136,290	130,900	134,610	128,660	130,200	129,150	122,010	127,330	122,920	128,240	125,440	114,380
Canada [5]	117,824	107,748	114,297	114,050	139,940	139,789	135,623	137,004	129,152	139,701	141,078	153,906
Egypt	111,846	101,038	107,989	106,694	106,260	102,620	98,812	102,109	97,755	98,672	99,589	86,842
France [3]	44,981	43,530	44,981	43,530	44,981	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Bahrein [3]	300,000	300,000	360,000	360,000	360,000	360,000	372,000	372,000	372,000	372,000	1,100,000	1,100,000
Others [3]	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Total	148,148,833	145,487,944	152,524,355	146,353,914	151,094,793	154,497,181	147,974,563	153,476,608	149,354,238	151,929,292	159,816,860	147,302,621

[1] Estimate. [2] Anglo-Iranian Oil Co. figures revised; fuel oil returned to the ground has been deducted. [3] International Petroleum Company's figures. [4] International Petroleum Company and Lobitos Oilfields Ltd. figures. [5] Includes natural gasoline production.

Russian Sakhalin included with Russia. Japanese Sakhalin included with Japan.

Official Crude Oil Production Figures for 1932 to 1937

	Average to Feb. 28 1937	Daily Average 1936	Total to Feb. 28 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	3,226,051	3,001,410	190,337,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Russia	520,339	524,348	30,700,000	191,911,200	176,688,100	168,648,700	149,901,900	149,719,000
Venezuela	397,819	436,900	23,471,322	159,905,526	154,021,599	140,784,805	120,882,802	119,596,512
Roumania	152,288	173,527	8,985,000	63,511,000	61,150,000	62,006,000	50,971,200	50,491,205
Iran	156,449	156,449	9,230,491	57,260,441	52,413,879	52,663,782	48,581,280	45,122,455
Netherland India	131,836	122,030	7,778,330	44,662,857	42,569,625	42,289,408	38,512,663	39,584,027
Mexico	138,247	112,095	8,156,564	41,026,724	40,434,902	38,167,022	33,904,882	32,802,285
Iraq	79,946	74,484	4,716,817	27,261,087	24,850,924	7,935,657	1,200,000	1,200,000
Colombia	55,694	51,246	3,285,931	18,756,110	17,617,645	17,340,724	13,157,127	16,834,956
Peru	46,958	47,415	2,770,534	17,353,778	16,835,206	15,936,937	13,923,281	9,899,266
Argentina	42,492	42,492	2,507,028	15,531,998	14,317,500	14,045,652	13,759,565	13,166,900
Trinidad	41,032	36,167	2,420,864	13,237,075	11,669,792	10,894,363	9,560,039	10,023,780
British India	25,734	26,071	1,518,287	9,541,966	9,227,496	8,997,399	8,721,655	8,600,312
Poland	9,990	9,773	589,400	3,577,000	3,612,000	3,697,617	3,858,085	3,905,230
Brunei	11,561	8,639	682,080	3,162,040	3,162,614	2,673,041		
Germany	8,456	8,504	498,897	3,112,480	3,054,023	2,266,964	1,712,823	1,824,019
Japan	7,323	6,515	432,041	2,384,378	1,848,656	1,484,962	1,337,761	1,575,333
Ecuador	5,775	5,252	340,733	1,922,215	1,725,354	1,655,062	1,622,624	1,573,857
Sarawak	4,065	4,253	239,820	1,556,660	1,811,297	1,948,044	2,289,472	2,274,043
Canada	5,000	4,110	294,984	1,504,287	1,447,204	1,422,869	1,162,541	1,044,412
Egypt	3,160	3,341	186,431	1,222,865	1,215,606	1,479,037	1,391,495	1,742,370
France	1,525	1,459	90,000	534,063	529,664	552,000	552,000	552,000
Bahrein	37,288	11,279	2,200,000	4,128,000	1,264,809	285,071		
Others	2,542	2,459	150,000	900,000	900,000	861,000	432,000	432,000
	5,111,569	4,870,218	301,582,554	1,782,499,750	1,638,763,904	1,506,101,116	1,424,331,195	1,296,672,962



World crude oil production by months, 1935–1937. Chart is weighted to compensate for variation in number of days per month. Ratio of U. S. crude production to world production.

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Industry. Edited by Dr. O. W. Willcox

PETROLEUM GEOLOGY

SPECTROGRAPHIC ANALYSES OF OIL WELL BRINES.—F. H. Emery, in OIL & GAS JOUR., vol. 35 (1937), No. 42, pp. 53–54.

In the drilling and operation of an oil well, any and all means of identifying the individual horizons through which the drill has penetrated assume a notable economic importance. In this paper the author reports work indicating that the spectrograph may be a means of distinguishing, or correlating, the brines found in or adjacent to oil formations. This is because the water in such formations, having different geological origins and past histories, will take into solution either different substances, or the same substances in different proportions. The spectrograph is easily able to detect the presence of chemical elements in quantities too small for convenient detection by ordinary analysis, and in much shorter time. A sample of analytical results on oil well waters by the spectrograph is given in the accompanying table.

Spectrographic Analyses of Oil Brines
(Results are in parts per million)

Sample No.	1	2	3	4	4,109	4,110
Element:						
Al	150	3	16	25	17	35
Ba	4	20	3	126	4	3
B	110	1.5	32	25	17	35
Ca	M	M	M	M	M	M
Cu	11	0.0	0.0	0.0	0.2	0.4
Fe	11	62	0	0	70	5
Pb	2	1.0	3	1	2	2
Li	21	3	5	4	5	5
Mg	M	M	M	M	M	M
Mn	0	0	0	0	4	4
K	21	5	16	4	5	5
Na	M	M	M	M	M	M
Si	42	5	16	13	35	35
Ag	0	0	0	0	0	2
Sr	1,100	780	790	630	880	870
Sn	9	0	0	0	0	0
V	5	4	4	3	4	4

M indicates element too high to estimate.

These analyses show differences beyond the range of probable error. Sample No. 1 is altogether different from any of the other samples; it contains the highest amounts of potassium. Sample No. 4 can be differentiated by the presence of considerable amounts of barium. Samples No. 4,109 and 4,110 are closely related, but the presence in No. 4,110 of a trace of silver serves to differentiate it from any of the others.

As applied, for example, to two well-known formations, the Hunton limestone and the Wilcox sand, ordinary chemical analysis shows that the waters of these formations differ only in their sulphate content. Spectrographic analysis shows that they differ also in barium content. The difficulty here arises that on occasion one formation will show less sulphate and more barium, or *vice versa* than the other; this raises an uncertainty which, however, is removed by taking into consideration the boron contents. The water from the Wilcox sand is very much higher in boron than that from the Hunton limestone.

The application of accurate spectrographic analysis of the rare elements in the brines should find its greatest usefulness in detecting the source of casing leaks, and a thoroughgoing application of the method might bring to light new relationships not now suspected.

MICROPALEONTOLOGY OF JACKSON EOCENCE OF EASTERN MISSISSIPPI.—Emil Monsour, in BULL. AMER. ASSOC. PETROL. GEOLOGISTS, vol. 21 (1937), No. 1, pp. 80–96; 1 fig.

This paper is essentially a check list of the *Foraminifera* and *Ostracoda* which occur in the Garland Creek-Shubuta Bridge section of the Jackson Eocene of Clarke and Wayne counties, Mississippi, as described by the Shreveport Geological Society guide book for their eleventh annual field trip. The check list contains an analysis of the micro-fauna of other noted Jackson localities. From the check list, the writer has attempted to show how the Jackson Eocene may be subdivided for correlation purposes. He has called attention to the fact that the upper part of the section is closely related to the Red Bluff Oligocene.

GEOLOGICAL EXPLORATIONS IN PARTS OF BRAZIL AND PERU.—Victor Oppenheim, in BULL. AMER. ASSOC. PETROL. GEOLOGISTS, vol. 21 (1937), No. 1, pp. 97–110; 5 figs.

The northern Territory of Acre, in the Alto Juruá River area, Brazil, and the middle valley of the Ucayali River, Perú, have not been studied geologically heretofore. It is a sparsely inhabited region. Flat plains, swamps, and tropical jungle make precise geological work in a short time rather precarious. However, as this contribution emphasizes, stratigraphical and structural conditions in the northwestern Territory of Acre, particularly the Serra do Môa region, show possibilities of important petroleum accumulations and the area deserves detailed surveying.

The sediments range in age from Lower Cretaceous to Pleistocene and are of continental and marine intermittent deposition, although poorly fossiliferous. No rocks of igneous origin were observed. Tertiary and Cretaceous formations of the Pachitéa, Pongo de Manseriche, and Contamana areas, Perú, can be stratigraphically correlated with those of the Serra do Môa and upper Juruá areas in the northwestern Territory of Acre.

The structural characteristics correspond with the physiographical features. The Serra do Môa Range, of Andean folding and apparently the last eastern spur of the Cordillera Oriental, is an anticline in partly Cretaceous beds, traversed by several tributaries of the upper Juruá.

Although oil seeps were not observed in the Serra do Môa region, they have been found in the headwaters of the Ahuaya River, a tributary of the upper Cashiboya River. The seeps occurred in faults in hard, red clay sandstones of the red-bed formation; the exact horizon from which the petroleum generated is not known since many seeps occur in Tertiary or Cretaceous outcrops. In the Pachitéa River district, seeps have been observed and drilling is planned for the near future by a private concern. The region of the upper Juruá geologically is a part of the potentially oil-bearing structural belt extending along the eastern foothills of the Andes, south through Bolivia into Argentina and north through eastern Perú into Colombia and Venezuela.

THE GEOLOGICAL SIGNIFICANCE OF SEISMIC REFRACTION MEASUREMENTS.—H. Reich, in OEL UND KOHLE, vol. 13 (1937), No. 3, pp. 53–59.

In such an undertaking as the general geophysical survey now under way in Germany, the refraction instead of the reflection method of seismic exploration must be used for the preliminary work. This is necessary because the reflection method says nothing about the physical character of the reflecting layers nor of the overlying layers. On the other hand, there is no better means of finding and delimiting a horst or other tectonic "high" than the refraction method. Reflection data always have to be interpreted with the help of known geological sequences, drill records, or refraction data. (Nothing is said about preliminary surveys with the torsion balanced. Ed.)

DRILLING

PRESENT TRENDS AND PRACTICES IN WELL COMPLETIONS.—A. W. Walker, before Production Division A.P.I., February, 1937 (O & G J, 1937, p. 35).

The advent of proration has made impractical, to a great extent, many of the older methods of valuation of oil wells, and has called for revisions in methods of well completions. This paper gives a summary of the more important recent improvements, and some of those which are just beginning to be used.

First to be noticed is pressure drilling with oil as drilling fluid, which has many advantages along with some disadvantages; the author raises a point not previously discussed. In the published, and other available data it is sometimes observed that within any single pay zone the productivity reaches a maximum very near the top of the zone and then declines. This can be interpreted as representing a condition of optimum potential due to the energy initially released in the associated gas, rather than as a reflection of the reserves. This is necessarily true because all other data may indicate that the sand is equally well saturated at the points of lower potential. Where this relationship is found, it should be given due consideration in the completion of the well. If it is desired to obtain maximum potential with natural flow, full penetration should not be taken, but if it is desired to obtain the highest potential with artificial flow and the greatest ultimate recovery, it, no doubt, will be necessary to take full penetration and case off the upper or gaseous part of the pay.

The recently introduced system of reverse circulation is simple and can be used with any type of drilling fluid, from regular mud to gas-oil mixtures. The necessary equipment is quite

simple; wells can be drilled-in with gas-oil mixtures, giving most of the advantages of the standard pressure-drilling equipment and eliminating excessive increases in cost. The principal end-result is low bottom-hole working pressures and an unclogged sand face.

Acidization of new wells, with or without shooting, is now common practice; it increases permeability, cleans the sand face, and materially increases the potentials of the wells.

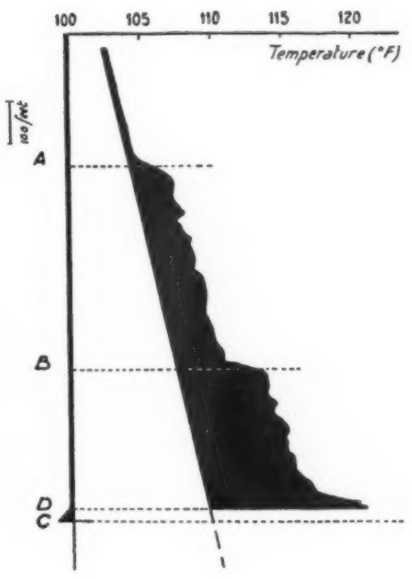
Casing completely through the productive horizons and then selectively gun-perforating the desired zones has become eminently practicable through the perfection of the gun-perforating methods. Each zone can now be evaluated separately and produced independently of the others.

There has been much improvement in drilling fluids. A pure colloidal mud has less penetration into the sand and is more easily removed than a non-colloidal mud. Oil-muds have been introduced experimentally, and appear to have wide possibilities. Among special muds is a prepared lime for cleaning out and drilling-in wells, being entirely removable from the face of the sand by HCl.

The technique of squeeze jobs, which are grouting operations to shut off undesirable water horizons or caving formations, has been much improved.

The construction of rotary core barrels has been steadily improved; better coring results, especially in Mid-Continent areas, have been obtained; better colloidal mud has also increased percentage recovery of cores in hazardous areas. This improvement in coring practice has resulted in much greater accuracy in determinations of porosity, oil and water saturation, permeability and net sand percentage. Drill stem tests have now almost become routine practice in certain areas for locating producing horizons and testing unknown strata. Electrical logging needs little comment. A recent development is the employment of temperature records for correlating beds and locating cement behind casing. Side-wall sampling has been developed as a valuable means of checking formation data in the softer beds of the Gulf Coast, but is less well adapted to the harder formations of the Mid-Continent area.

Locating top of cement



produces a considerable amount of heat. An actual example is illustrated in the accompanying figure.

The top of the cement is clearly seen to be at *A* (casing shoe at *C*). One will note that there is another sharp rise of temperature at *B*; this is due to the fact that the last sacks of cement were treated with an accelerator, and the setting and heat-emission phenomena are not the same in the two portions *AB* and *BC*. The temperature run thus shows up both interesting points. Finally, the rise at *D* is due to the cement existing both inside and outside of the casing just below this depth (plugs not yet drilled out).

engine to be at least fairly satisfactory, but that the usual drawworks, even of the most improved type, is the maximum of inefficiency and crudeness. As now constructed and operated these drawworks subject the engine to unnecessary shock, put excessive strains on the chain drives and impose unreasonable and unsafe stresses on the drilling or casing line; and the brakes and brake linings are in crying need of improvement. The remedy is to be sought in gear-driven hoists, friction clutches, and brakes with full effective braking surfaces. Excuses offered by manufacturers for failure to provide these improvements are lame.

The present rotary table seems a satisfactory piece of equipment, but its drive is neither satisfactory nor economical. There is a tendency to build the table too large, and it is driven by a greatly overpowered prime mover, which subjects the delicate drill pipe to unbearable shock and strain. An obvious improvement is the use of a properly powered prime mover that will stall before subjecting the drill pipe to undue fatigue in the event of bit stalls. The situation calls for the use of variable cut-off reciprocating engines, or electric drive with the proper type of motor.

Little or no fault is to be found with the Kelleys and the drill or bit collars, nor with the quality of steel used for the drill tubes, but the V-shaped threading of the tool joints is not satisfactory; it is in these threaded joints that fatigue breaks occur, entailing innumerable and costly fishing jobs; the thread form of these joints must be changed. Another crying need is a machine capable of feeding the drill bit into the formation smoothly and continuously instead of intermittently.

Another way to economy is the unitizing of drilling rigs to facilitate easy handling. The advantage of instrumental records of drilling operations is not generally appreciated. In considering prime movers other than steam (which is still the most satisfactory) the author gives preference to the direct current motor fed by Diesel-electric generators. Finally, the author considers the question: "Why all this fuss about improvements?" The answer is that the oil industry and the consuming public need more and cheaper oil wells.

Temperature Measurements in Oil Wells.—M. Schlumberger, H. G. Doll and A. Perebinossoff, in JOUR. INST. PETROL. TECHNOLOGISTS, vol. 23 (1937), No. 159, pp. 1–25.

Continuous temperature measurements in oil wells can now be made with an extremely sensitive recording thermometer. They can be applied to a great number of oil-field problems, both in wells in thermal equilibrium and in wells in thermal evolution, and also both in open and in cased holes.

The data on geothermal gradients and their variations interest both the regional and local geologists. Knowledge of subsurface temperatures can aid the technologist in problems related to mud and cementing.

Temperature measurements can yield valuable corroborative data on the sequence of formations in a well, the main data always preferably being given by electrical logging. They can be applied to location of water, oil- or gas-sands, both in drilling and in already tested or produced wells. They are invaluable for checking the results of a cementing operation.

The paper presents the principles of the major thermometric techniques, and illustrates them with some practical examples. In conclusion, attention is drawn to the time and care that may sometimes be required for optimum results, but practice has already proven that the best local operating conditions are very soon determined in most regions, thanks to the spirit of cooperation existing between the surveyor and the local technologists.

An interesting application of temperature measurements in oil wells is locating the height to which the cement has risen behind the casing after a cementing job. In setting, the cement

Needed Improvements in Rotary-drilling Equipment.—J. E. Brantly, in WORLD PETROLEUM, vol. 8 (1937), No. 2, pp. 62–66, 86.

The author, himself an experienced and successful operator of rotary drilling equipment, is severely critical of both manufacturers and users of rotary-drilling outfits. The general use of the rotary method dates back to the old Spindletop field on the Gulf Coast about 1900, and except in a few particulars, from that day to this there have been no radical changes in the general plan of operation or in the rotary-drilling machines themselves.

The object of the paper is to particularize the points wherein improvement appears not only possible, but also highly desirable—even urgent. In the matter of steam power-plants for heavy-duty rigs a change from the ordinary locomotive-type boiler to one embodying the useful features of the water-tube boiler combined with a superheating arrangement, should result in a much more efficient steam-generating unit. Improvement in this most important part of the drilling rig can and must be made. Another point that comes in for criticism is neglect of the obvious economy of hot boiler feed water by saving the heat of exhaust steam.

As regards the mud circulating pumps, the direct acting type now in common use is ideal where fuel costs nothing and water is over-abundant, but where fuel is costly and water scarce or of poor quality it is the most uneconomical piece of machinery imaginable. There are now available power pumps driven by multi-cylinder variable cut-off reciprocating engines which show astounding reduction in steam consumption.

Passing from the pumping plant to the derrick floor, the author finds the ordinary hoisting

OIL WELL OPERATION

Water Control in Oil Wells by Air Pressure.—F. R. Cozzens, in OIL WEEKLY, vol. 84 (1937), No. 5, p. 18.

Of all known agents fresh water is the most destructive to oil-bearing sands. Present developments in two Ohio fields demonstrate the success of air pressure in controlling the difficulty.

When fresh water is first noticed in a producing oil well the general practice is to remove the tubing and rods, and attach a valve-head to the casing. Air furnished by a stationary engine-driven compressor, usually of 6-cylinder construction, is next forced down the hole. When pressure at the casing head registers 800 to 1,000 pounds, the valve is opened and allowed to blow-off. Of course, both the oil and the water in the sand are under the same pressure but the oil, being confined in the sand nearer the well is the first to return to the pocket or reservoir. Pumping equipment is then installed, and the accumulated oil withdrawn. As the oil is pumped from the reservoir, the water naturally replaces it. However, as great quantities of water were forced deeper into the recesses of the sand during the period of air pressuring, the amount reaching the well is correspondingly less. When its appearance is again noticed, air pressure is applied a second time and in the same manner. Three to five such treatments usually suffice to check the water menace in ordinary wells. In many cases wells

abandoned for years because of water have been brought back into normal production within a period of three months.

Water control, managed by air-pressure is proving especially valuable in the re-drilling of abandoned territory where surface water has crept in from improper plugging of old wells. In certain districts it has been possible to force the water back to the vicinity of its source where it can be readily pumped out. Equity Oil & Gas Company recently carried out this process to a point on a lease near Chesterhill, Ohio, where an accumulated volume of water was blown out of an abandoned well by air-pressure, registering 1,000 pounds. In 2,000-ft. territory in the vicinity of Zanesville, Ohio, similar good results are being obtained from suction pumps. In the more porous sands of southern Ohio and West Virginia, the general procedure is to force water entirely out of the rock into shales underneath by pressure of 1,000 to 1,200 pounds. In practically all cases, there has been a gradual return of oil as water receded, and careful checkups show marked improvement in sand texture and productiveness.

Corrosion of Steel by Oil Well Waste Waters.—W. F. Rogers and W. A. Shellshear, in IND. ENG. CHEM., vol. 29 (1937), No. 2, pp. 160–166.

Oil waters of corrosive and non-corrosive types were sampled and studied to determine the cause of their corrosion rates. The matters looked into were concentration of hydrogen ions, quantity of neutral soluble salts, hydrogen sulphide, oxygen, and ratio of oil to water. It is concluded that when oxygen is absent there is no corrosion that can be attributed to neutral salts or to hydrogen sulphide, regardless of the quantities of these substances that may be present. When oxygen was purposely added during the tests the rate of corrosion was greatly increased.

The presence of oil tends to mitigate the effects of corrosion; when as much as 30 percent of oil is present the metal is to some extent protected. Corrosion is evenly distributed and of a low penetration rate, and the protection increases as the proportion of oil increases. However, quantities of oil below 30 percent do not greatly reduce the rate of corrosion by oxygen-bearing waters.

A Study of Oxidation of Oil in Two Air- and Air-Gas Repressuring Projects.—T. W. Johnson and S. S. Taylor, in BUREAU OF MINES REPORT OF INVESTIGATION, January, 1937.

In view of the common practice of increasing the recovery of oil from partly depleted oil sands by injecting into the sand air or a mixture of air and gas, the question arises as to the possible effect of the oxygen of the air on the crude oil.

Laboratory experiments have been conducted by the Bureau of Mines to determine the effect of air on crude oils. In these experiments the crude oils were oxidized by the air, and the degree of oxidation depended not only upon the chemical composition of the crude oil but also upon the duration and method of contact between the oil and air, the temperature of the fluids and the concentration of the oxygen. When the crude oils were oxidized the following results and changes in the oils were obtained:

1. Carbon dioxide was produced.
2. Asphaltic materials and gums insoluble in the crude oil were formed.
3. The acid value of the crude oil was increased.
4. The surface tension of the crude oil remained virtually unchanged.
5. The interfacial tension between the crude oil and water was decreased.
6. The data obtained by the Bureau of Mines-Hempel distillation method showed no appreciable difference between oxidized and unoxidized oils.

Following the laboratory tests a study was made of the oxidation of oil in two commercial repressuring projects in which air and air-gas mixtures were used as the repressuring media. One of these projects was in the Martha field, Kentucky, the other in the Delaware-Childers field, Oklahoma.

In summarizing the results of observations continued for about a year it is noted that in the first division of the experiment the gravity of the oil from the repressured areas was somewhat lower than that of oil from non-repressured wells, but it is not clear that repressuring was responsible. In this part of the experiment the viscosity of the oil from the repressured area was less than that of the oil from the non-repressured wells; in the other field there was little or no difference.

However, evidence that oxidation of the oil occurs as a result of air repressuring is seen in a reduction of the interfacial tension between the recovered oil and water; the practical result of this reduction of the interfacial tension is a greater readiness of the oil to emulsify. On the other hand, a Bureau of Mines-Hempel distillation did not disclose any definite change in the oil due to repressuring or to the different repressuring media.

Bottom-Hole Flowing Pressures.—S.F. Shaw, in OIL WEEKLY, vol. 84 (1937), No. 5, pp. 21–28.

Bottom-hole pressure and casing size are critical factors in determining the yield and the life of an oil well. If the casing is small a higher bottom-hole pressure is required to force the oil to the surface than where the dimensions of the casing are more ample. Here is a fact that does not seem to be duly appreciated. For example, the use of 6⅝ and 7-inch O.D. casing in the Oklahoma City field has been disastrous for maintaining production when the wells cease to flow naturally and it has become necessary to reduce area by running tubing in order to flow the well artificially; whereas if larger casing had been used the wells might have produced naturally until the reservoir pressure declined to a comparatively low point. It has been shown that in the thick, highly permeable sand of the Oklahoma City field, a differential pressure of approximately ten pounds per square inch is capable of permitting a production of 2,000 bbl. a day, but this is possible only with large size casing.

The same fault of using small diameter casing appears in the way of being committed in various Gulf Coast fields where depths of 5,000 ft. or more are reached. If low permeability sands are encountered and reservoir pressures have declined below 500 pounds, it will be possible to obtain low lifting costs only at low rates of production, with the offsetting disadvantage that the wells would probably need to be abandoned long before a high percentage of ultimate recovery had been obtained.

One advantage of the high rate of production permitted by large diameter casing is that operating costs are much lower when operating at high capacity for only a short period each month (as under proration) than when operating at restricted capacity throughout the full month. The lease attendants can be transferred from well to well, depending on which well is being flowed, thus effecting a saving in lease labor as well as in compressor plant operation.

PIPELINES

The Bakersfield—Martinez (Calif.) Pipeline.—F. B. Sims, in PETROLEUM WORLD, vol. 34 (1937), No. 2, pp. 75–111.

The superintendent of the Shell Oil Company's pipelines in California here describes the construction and operation of the new 312-mile pipeline from the Bakersfield oil field to the new Martinez refinery. In this system a number of interesting engineering designs have been incorporated, chief among which are provisions that make the system elastic enough to move oils of various grades from the lowest to the highest gravities economically.

However, the most viscous oil was the controlling factor, so the line was designed to operate most economically under full load when moving the heaviest oils under extreme winter conditions. In order to do this it was necessary to provide a so-called hot oil line. This involved the erection of heating equipment at each of the 10 pumping stations between the oil field and the refinery. At these stations the oil is passed through 48" x 20' tube-length low pressure heaters and a high-pressure 26" x 18' tube-length heater. The capacity of these heating systems is such that the oil stream may be raised to a temperature of 180 deg. F. at a pressure of 800 to 1,000 lbs., the rate of flow being 1,200 bbl. per hour. The main pipeline leaving each station is 10 inches in diameter; since the oil begins to cool as it leaves the station, the 10-inch line merges into a 12-inch line about two-thirds of the distance to the next station. In this manner the losses of temperature and the corresponding increase in viscosity as the oil travels along and cools are compensated by an increased diameter of the conduit. The new line parallels an old line of smaller diameter that is used as a constant-temperature light oil line. The paper describes the various features of the line with precise attention to engineering detail.

New Gas Line in Pennsylvania.—J. C. Albright, in OIL WEEKLY, vol. 84 (1937), No. 10, pp. 35–37.

An account is given of the construction of a new gas line laid down by the People's Natural Gas Co. from Coudersport to New Bethlehem, Pa. The line is 103.3 miles long and 12¾ inches outside diameter. It is designed to transport approximately 26,000,000 cu. ft. of gas a day at a maximum pressure of 500 lbs. No compressor stations are provided, as the wells in the Hebron gas field have sufficient rock pressure to transport the desired quantity without boosters.

As a construction job this new line was distinguished by the necessity of much excavation in rock, requiring the use of about 100 tons of 40 percent dynamite; machine excavation tools were unusable except on top of the flat ridges and along the narrow valleys of the creeks and rivers. Instead of carrying the line across the streams on trestles or pipeline bridges, the crossings were made by laying the pipe below the water. This involved the blasting out of the temporarily dammed river beds (using sand bags which enclosed approximately half the stream). At such places the line was arc-welded and laid in a concrete bed, and concrete fill was poured into the chiseled cut in the solid rock to imbed the pipe firmly and so prevent damage from outside forces. Away from the creeks the line was laid bare and unprotected, without coating or wrapper of any sort—except in spots contaminated by "coal blossom", or other evidence of the presence of injurious chemical. Except for the welded stream crossings, the line was made up by using approximately 13,700 bolted couplings.

Progress in Electric Welding of Pipelines.—A. F. Davis, in PIPE LINE NEWS, vol. 9 (1937), No. 4, pp. 8–10.

A review of pipeline construction during the year 1936 indicates a very decided trend toward use of electric welding in joining the pipe. Of the total of 3,737 miles of oil, gas and gasoline lines laid during 1936—lines 20 miles or more in length and 6 inches or more in diameter—2,617 miles were electric welded. This indication of the widespread acceptance of electric welding is particularly interesting when it is realized that the first electrically welded line, over 50 miles in length, was laid only slightly more than seven years ago, in 1929. During that comparatively

short period, over 25,000 miles of line, involving more than 1,000,000 joints, have been welded electrically.

Responsible for this steadily increasing use of electric welding is the inherent simplicity of the process and the marked improvement in equipment and procedures, permitting fast welding speeds and consistent production of welds possessing physical properties better than those of the pipe itself.

One of the outstanding developments of 1936 in the electric welding of pipelines is the use of the so-called "stove-pipe" method. This method, in which one joint is laid at a time and welded accordingly—all the welds being bellhole or position welds—is particularly applicable when a line is being constructed through rough or muddy terrain where it is difficult to complete more than a mile of line per day. Under the conditions cited, the "stove-pipe" method is less expensive than the usual "firing-line" method. The reason for the economy is that the use of a lineup crew—the function of which on the firing line is to line up the pipe preparatory to welding—is eliminated. Therefore, the cost of the lineup crew, which averages between $60 and $80 per day, is saved.

Although the "stove-pipe" method is used to considerable advantage when employed in electric welding of pipe in rough, muddy, swampy country, the method employed under generally favorable conditions is the use of plain butt joints on straight end pipe.

Accounting for the steadily increasing use of electric welding in construction of oil and gas lines is the constant improvement, by manufacturers, of electric welding machines and equipment. The modern pipeline arc welder is as far ahead of its predecessor, in performance and economy as it is in appearance. The new machine is equipped with an entirely new system of arc control which permits continuous adjustment of both arc heat and arc penetration in a continuous sequence of fine increments. This advanced feature makes the arc welder simpler and easier to operate than ever.

NATURAL GAS

Gas Purification with Sodium Phenolate.—Anon., in REFINER, vol. 16 (1937), No. 2, pp. 90-91.

The first commercial installation of the Koppers sodium phenolate gas-purification process is now in operation at the El Segundo refinery of the Standard Oil (Calif.) Co. It is designed for treating 13,000,000 cu. ft. of cracked gas a day containing 4.5 percent of hydrogen sulphide, from which there is produced an average of 85 tons of sulphuric acid a day. A similar plant will be erected by the Atlantic Refining Co. in Philadelphia to treat 22,000,000 cu. ft. of refinery still gases at 225 lbs. pressure; here also the hydrogen sulphide will be converted into sulphuric acid and the purified gas used for polymerization.

Sulphur recovered by the sodium phenolate process is in a form readily adaptable to the manufacture of sulphuric acid by any of the conventional methods. Often there is sufficient sulphur in the cracking-still gas generally burned under boilers to supply the acid requirements of the entire refinery, and at a cost which may be as low as 50 percent of contact acid cost. Acid plants of modern type used for converting hydrogen sulphide gas into sulphuric acid are simple compact units which are practically automatic in their operation and require no special type of labor and supervision other than the usual refinery personnel.

The purification system consists of an absorption stage and an actification stage through which the sodium phenolate solution is continuously circulated. This solution has a high carrying capacity for hydrogen sulphide, amounting to 2,000 to 4,000 net grains per gallon. As a result, it is necessary to circulate only five to ten gallons of solution per thousand cubic feet of gas. The low circulation rate contributes to low operating expense and the simplicity of equipment required.

Increasing Importance of Gasoline Manufacture from Gases.—C. O. Willson, in OIL & GAS JOUR., vol. 35 (1937), No. 40, pp. 21-22.

Twenty-five installations for the manufacture of gasoline by polymerization of gases are now operating or under way, involving expenditure in excess of $20,000,000.

These initial plants will manufacture 25,000 bbl. daily of high octane gasoline. Possible output from industry's available gases, based on present development of art, is many times this amount. Higher price levels will extend its applications. It is significant as a conservation measure, as every barrel of polymerized gasoline, obtained from gases now used as fuel or wasted, reduces crude oil requirements two bbl.

In this connection, many are coming to consider all gas in pounds, rather than in cubic feet which helps to visualize the possibilities of gas when considered as raw material in the production of finished products. For example, the approximately 2,200,000,000 m.c.f. output of natural gas last year based on an average weight per thousand cubic feet is equivalent to more than 300,000,000 bbl. of liquid petroleum. The bulk of natural gas by weight is methane, a refractory hydrocarbon, not suitable for the present commercial polymerization operations, a situation which may change later. Other investigations have attempted to estimate the quantity of butane, propane and other hydrocarbons which can be cracked and polymerized, but which are now either blown into the air or burned as fuel. One report showed that the potential supply of polymerized gasoline available from the residue gas of several hundred natural gasoline plants exceeded the 1,765,722,000 gallons natural gasoline compressed and absorbed from the gas in the plant operations. This figure included the butane and propane removed from the finished gasoline in the stabilizing operations. The extension of polymerization to include this raw material appears to be largely dependent on the working out of plans to collect and transport the gases to central points for processing.

PETROLEUM REFINING

Hydrogenation of Coal at Lievin, France.—Etienne Aubibert, in GENIE CIVIL, vol. 108 (1936), No. 22, pp. 514-516.

At the experimental coal hydrogenation plant at Lievin (capacity—50 tons of coal a day) the coal is finely ground and suspended in a supporting oil; this mixture when warmed up is sufficiently fluid to be pumped if the proportion of coal does not exceed 50 percent. Besides serving as a fluid vehicle the oil serves to dissolve the principal constituents of the coal (fusain, clairain, vitrain) which are supposed to be highly condensed hydrocarbons with molecular weights of the order of 100,000, resulting from the polymerization of compounds having molecular weights of 1,000 and relatively low melting points; the theory is that these complex coal-compounds are broken down by heat, the decomposition products melt, and are dissolved in the supporting oil; the solid coal is thereby converted into a liquid phase. This is important, as catalytic hydrogenation reactions occur only in the liquid or vapor phases, and not in the solid phase. When this liquid phase has been attained the hydrogenation process in the presence of a catalyzer begins at 450 deg. C. A part of the supporting oil is always attacked by the hydrogen under pressure, producing, like the coal, gases, gasolines and heavy oils that can be returned to the process as supporting oil. The process is therefore so regulated that the amount of heavy oil formed will be just sufficient to continue the process, so that the only materials consumed are coal and hydrogen.

The volatile products obtained by hydrogenizing in the liquid phase are separated into fractions which are directly usable as gasoline, and a fraction which yields an additional quantity of gasoline when hydrogenated in vapor phase.

The manufacture of a ton of gasoline consumes an average of 1.5 tons of coal and 1,800 cubic meters of hydrogen; the energy consumed is about 640 kilowatt hours. During the process there are produced 400 kilograms of gaseous hydrocarbons containing 1,000 cubic meters of hydrogen. When treated with water vapor these gases can furnish about 2,000 cubic meters of hydrogen, which is more than is needed in the process. This is an important point, as it is unnecessary to use outside materials in order to obtain hydrogen, the cost of which has a great influence on the cost of manufacturing the synthetic gasoline.

The gasoline obtained by this process consists of 12 percent of olefines, 40 to 70 percent of aromatic compounds, and 30 to 45 percent of saturated hydrocarbons; sulphur is less than 0.1 percent and the octane number is 60 to 85.

New Clay Filtration Method.—J. C. Albright, in REFINER, vol. 15 (1936), No. 12, pp. 555-558.

At the Rouseville refinery of the Pennzoil Co. bright stocks and steam refined oils are treated with California and Mississippi clays having a fineness of 200 mesh. The first step is to make a slurry of the clay with a small portion of the oil stream; the production of this slurry is continuous, a certain weight of clay per minute being delivered in a constant stream to a small mixing tank. The clay-oil slurry is then delivered to the top of a more or less conventional type of tube still where it is mixed with the incoming main stream of crude. After passing through the various pipes and headers of the tube still, wherein the mixture is processed at a suitable temperature, it enters above the seventh tray of a fractionating bubble tower, where various fractions are flashed from the top and sides. The heavier fractions travel to the bottom of the still and the clay and reduced crude are delivered to filter presses. These presses are in duplicate, and operate on a strict time schedule.

When this system was installed it was expected that clay would be deposited on the plates, but no such trouble has been encountered; the clay seems to remain in complete suspension. The presses are opened and closed by hydraulic action. The spent clay has found satisfactory use as a road surfacing.

Production of Isoparaffins by Thermal Gas Polymerization.—F. E. Frey, in OIL & GAS JOUR., vol. 35 (1937), No. 34, pp. 40, 46, 48 and 49.

Gas polymerization to produce motor fuel is now a familiar development and is of interest to the natural gasoline industry because of the increased volume of gasoline to be obtained from natural gas by the conversion of the normally gaseous butane, propane, and ethane content. Its value to refiners lies in the conversion of still gases with consequent increase in gasoline yield derived from crude.

Under suitable conditions it is possible to convert paraffinic gases such as propane and butane into gasoline in a single conversion step, in which splitting to produce olefins and polymerization to produce gasoline take place at the same time. Keith and Ward have described a unitary thermal conversion process in which gasoline may be produced by heat and pressure treatment in a single reaction zone without the presence of a catalyst.

A typical application will serve as an example. Conversion stock is suitably propane and butane, which may be extracted from natural gas, or the corresponding hydrocarbons extracted from cracking still gases which contain, in addition to these paraffins, some olefins. These extracted gaseous hydrocarbons may be handled under sufficient pressure to maintain them as liquids at ordinary temperatures and they are pumped as liquid to a conversion pressure of 1,000 to 3,000 pounds per sq. in. The liquid under pressure is then passed continuously to a tube coil in a furnace in which it is heated to a reaction temperature of 950 deg. to 1,100 deg. F. and allowed to react to the desired degree as it flows through the tube coil. The reacted hydrocarbons are discharged into a fractionating system and three fractions separated; namely, the light gas (largely methane) which is discharged; heavier gases consisting mostly of unconverted propane and butane, plus some C_2 hydrocarbons, which are recycled to the charge pump as liquid, and gasoline. The gasoline contains a very small amount of oil heavier than gasoline which is removed in the fractionating system.

This, in a general way, is one manner in which thermal polymerization is conducted. The remainder of this paper is devoted to showing how the thermal polymerization reactions can produce isoparaffins of special design.

The method used is to make selected mixtures of olefins and paraffins in various proportions and pass the mixture under about 4,500 lbs. pressure through tubes heated to around 950 deg. F. The 2-2-dimethyl butane, a hexane, was the chief paraffin synthesized from ethylene and isobutane, with an A.S.T.M. octane number of 94.5 (unleaded).

Influence of Water on Bleaching of Oils with Fullers' Earth.—A. Berczeller and E. Erdheim, in PETROLEUM, vol. 33 (1937), No. 4, pp. 6–8.

Certain firms dealing in earths for bleaching oils have put out prospectuses indicating that, contrary to the general impression, the presence of water in the oil facilitates the bleaching process and results in a higher degree of decoloration. To verify these statements the authors instituted a series of investigations on vegetable and mineral oils. The results show that the presence of water does, in fact, have a favorable influence on bleaching, particularly in the case of vegetable oils. The effect varies greatly, the improvement in color ranging from 1.5 to 35.7 percent in comparison with bleaching in the absence of water. Differences are observed in the reaction of the same oil to different earths. The amount of added water was around 30 to 40 percent, figured on the weight of earth taken.

The results are less decisive in the case of mineral oils (6 to 7 deg. Engler). In the few experiments with this class of oils here reported the decoloration was no better in the presence of water, and in most cases was not as complete.

Such effect as water has in this connection is supposed to result from an alteration of the character of the coloring material (possibly a hydration) with formation of an ionizable color lake that is more easily absorbed by the earth.

Catalytic Hydrogenation of Japanese Shale Oil.—Y. Kosaka and K. Tanaka, in JOUR. SOC. CHEM. IND. (JAPAN), vol. 39 (1936), No. 12, pp. 475B–478B.

Fushun shale oil was hydrogenated under 100 kg/cm² pressure at 385 deg. C. for three hours, using various catalyzers, among which oxides of nickel, cobalt, molybdenum and ammonium molybdate proved the most effective. Combination catalyzers consisting of Japanese acid clay (6 to 10 percent) and sulphur (0.5 percent) along with ammonium molybdate (3 to 6 percent) also proved effective. The higher the ratio of hydrogen to oil the larger the yield up to a ratio of 0.045, beyond which the yield increased but slowly. The hydrogenated oil obtained in the process was mostly light in color and of good quality, containing 17 to 18 percent of crystalline paraffin melting at above 50 deg. C.

PETROLEUM CHEMISTRY

Composition of a Yates Gasoline.—C. O. Tongberg, M. R. Fenske and J. E. Nickels, in IND. ENG. CHEM., vol. 29 (1937), No. 1, pp. 70–73.

Fractional distillation of 45 gallons (170 liters) of a Yates straight-run gasoline run in a standardized manner yielded considerable information regarding its constitution. The gasoline was found to differ from other gasolines of paraffin type. A study of the fractions obtained showed that the gasoline consists mainly of naphthenes and branched paraffins. Methylcyclohexane and ethylcyclohexane were isolated and identified. No normal paraffins were found. Aromatic hydrocarbons are present in but negligible amounts below 157 deg. C. (315 deg. F.). However, certain fractions, with a lower refractive index and density than other fractions, have higher octane numbers.

Obtaining Nitrobenzene from Gasoline.—V. Th. Cerchez, in BULL. MATH. PHYS. (Bucarest), vol. 6 (1935), Nos. 1, 2, 3, pp. 151–154.

Roumanian gasoline frequently contains appreciable proportions of aromatic hydrocarbons (benzene, etc.), which are an important raw material for the manufacture of explosives. To obtain these hydrocarbons in a pure state would require a tedious and expensive fractionation of the gasoline, so the idea was broached of treating the gasoline directly with nitrating acid (HNO_3: $H_2SO_4 = 1$: 1.5) and then removing the nitrated products by distillation. The results showed that under these circumstances the nitration is never complete, as the residual gasoline invariably contains a notable proportion of unnitrated aromatics.

Thermal Reactions of Ethylene.—Robert E. Burk, Bruce G. Baldwin and C. H. Whitacre, in IND. ENG. CHEM., vol. 29 (1937), No. 3, pp. 326–330.

Although the field of polymerization has become of great practical importance not only to the petroleum industry but to various other industries, no really clear and acceptable explanation of the mechanism of such reactions has been presented. The noncatalytic polymerization of ethylene should constitute a particularly simple and fundamental contribution to the general understanding of polymerization. Yet prior researches on the subject have been in disagreement in important respects.

The prior work is arranged to show the various concepts which have been put forward relative to the mechanism of ethylene pyrolysis. They are:

1. Mechanisms involving the primary decomposition to carbon.
2. Mechanisms involving the primary formation of acetylene.
3. Mechanisms providing for the direct polymerization of ethylene to butylene as the primary step.
4. Mechanisms in which butadiene is thought to play an important part in the reactions and in some cases thought to be a primary product.
5. Other investigations where important observations were made, such as the prominent formation of ethylene, but which were not definite as to mechanism, or where the primrary formation of cyclobutane was thought possible, or where a free radical mechanism was assumed.

Not only have various mechanisms been proposed for ethylene pyrolysis but the experimental observations are not in agreement. One cause for this is no doubt that one or more primary reactions are occurring, different primary reactions being brought out by varying conditions of the investigations. A second possible cause is that traces of oxygen catalyze the reactions. A third cause of discrepancies in experimental observations is faulty analytical procedure.

The thermal reactions of deoxygenated ethylene were studied at 625 deg. C. and with various addition agents chosen to elucidate the mechanism. These results, together with the vast amount of prior work, may be represented by the dual mechanism:

I. $2C_2H_4 \rightarrow C_4H_8$ $\qquad C_4H_8 + C_2H_4 \rightarrow \begin{matrix} 2C_2H_4 \\ \text{liquids} \end{matrix}$

II. $C_2H_4 \rightarrow C_2H_2 + H_2$, $C_2H_2 + C_2H_4 \rightarrow C_4H_6$ $\qquad C_4H_6 + C_2H_4 \rightarrow \text{liquids}$ (with $+ H_2$)

I or II may be emphasized by suitable choice of conditions. Gaseous paraffins formed in small quantity are accounted for by hydrogenation of the corresponding olefin or as thermal decomposition products.

Non-Knock Fuels from the Lower Olefines.—S. F. Birch, F. P. Bim and T. Tait, in JOUR SOC. CHEM. IND., vol. 55 (1936), No. 49, pp. 335–337.

Primary, secondary and tertiary aliphatic alcohols were treated with sulphuric acid to obtain unsaturated compounds that, when subjected to catalytic hydrogenation, yielded the corresponding paraffinic hydrocarbons. The result is a series of substances having more or less pronounced anti-knock properties. Chief among these are alpha-isononane with an octane number (o.n.) of 98, isodecane (o.n. 94.8), beta-iso nonane (o.n. 94), and beta-beta-gamma trimethyl pentane (o.n. 100.2).

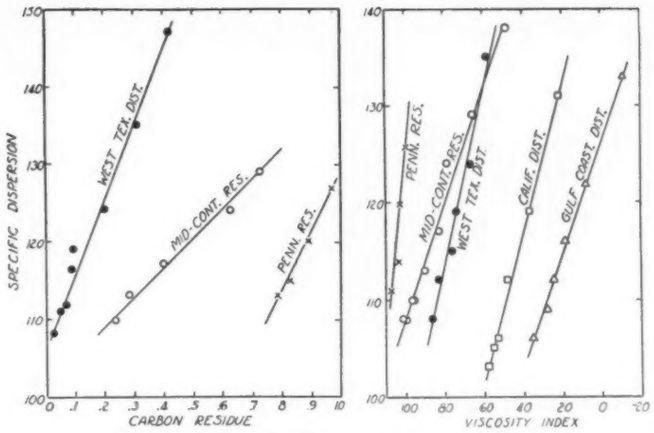
PETROLEUM PHYSICS

Effect of Solvent Extraction on Aromaticity of Lubricating Oils.—G. H. von Fuchs and A. P. Anderson, in IND. ENG. CHEM., vol. 29 (1937), No. 3, pp. 319–325.

In this paper the term "aromaticity" of lubrication oils refers to their content of the aromatic hydrocarbons. The two other classes of constituents of lubricating oils are the paraffinic and the naphthenic hydrocarbons. The difference between various types of oils is due not so much to different types of constituents but to variations in their relative ratio, some constituents being more desirable than others. The aim of solvent extraction is to change this ratio, separating the less desirable from the desirable constituents by physical means.

Among chemical constituents, the aromatics are the least desirable and the ones most generally removed on refining; and when an oil is refined the improvement is in proportion to the extent to which this removal is effected. The criteria at present used for identification and classification of lubricating oils are gravity, viscosity index, viscosity-gravity, viscosity-slope number, refractive index, etc. These properties are more or less unrelated and throw little or no light on the chemical constitution of the oil.

Certain tests are known and used for estimating the aromatic content of an oil, such as repeated extraction with sulphuric acid or some solvent such as furfurol, but such methods are tedious and not very accurate. The aniline point method is widely used, but it is affected by the naphthenes



(*Left*). Relation between Aromaticity and Carbon Residue

(*Right*). Relation between Aromaticity and Viscosity Index

and the average molecular weight of all the constituents so that under certain circumstances the aniline point test is uncertain and even meaningless. Various more or less serious objections can be raised to other methods in current use.

The authors now come forward with a procedure for determining aromatics in oils by a specific dispersion method. This method is founded on the fact that refractivities for lights of different wave-lengths of the saturated (paraffinic and naphthenic hydrocarbons) are very nearly the same, whereas the presence of the double bonds that characterize the aromatics confers on these hydrocarbons higher refractive indices, or dispersion. The matter thus becomes one of working out a method for measuring the dispersion, for which purpose the authors have constructed a new dispersometer and here describe its use. They characterize their method as superior to other methods, and vouch for the fact that it is invaluable for following the course of solvent refining of lubricating oils.

The relation between aromaticity and oil improvement in solvent extraction is demonstrated in the two accompanying diagrams, from which it may be seen that a direct and nearly straight-line relation exists between specific dispersion and such oil properties as Indiana oxidation test, carbon residue and viscosity index for each individual stock.

Determining Kinematic Viscosity with Technical Viscosimeters.—H. Vogel, in OEL UND KOHLE, vol. 13 (1937), No. 7, pp. 153–155.

The author shows that the formula previously developed by him for converting technical viscosimeter degrees into kinematic viscosities holds not only for the Engler and the Redwood viscosimeters but also for the Saybolt viscosimeter; the formula thus acquires a general importance.

For the Saybolt viscosimeter used by the A.S.T.M. for setting up its conversion table, and also for the apparatus used by McCluer and Fenske in their work the formula is

$$\nu = \frac{S}{29,3} \cdot 6,32\left[1-\left(\frac{29,3}{S}\right)^3\right]$$

in which ν is the kinematic viscosity and S the observed viscosity in Saybolt seconds. It is shown, however, that it is impossible to establish a single conversion table for a whole viscosimeter type; it is necessary to set up a special table for each individual viscosimeter.

For calibrating technical viscosimeters for making measurements in absolute units it is necessary to establish two calibration values, the water value and the apparatus constant.

The result of this work is to show that any technical viscosimeter can be used for directly determining kinematic viscosities. This makes it possible for laboratories, which do not possess an apparatus for such direct determinations, to calibrate their ordinary instruments so as to give the results in absolute units.

The System Sulphur Dioxide-Decalin.—W. F. Seyer and W. F. Cornett, in IND. ENG. CHEM., vol. 29 (1937), No. 1, pp. 91–92.

One of the most useful refining agents in the petroleum industry is sulphur dioxide; hence any data concerning solubility relations between this liquid and hydrocarbons will be of interest. In this paper are given thermal data for the system liquid sulphur dioxide-decalin (this latter substance is decahydronapthalene). The critical solution temperature is 28.3 deg. C. higher for decalin than for cyclohexane. The shape of the freezing curve indicates a difference in solubility of the two forms of decahydronapthalene.

BOOKS

Absorption and Extraction.—by Thomas K. Sherwood. Published 1937 by McGraw-Hill Book Co., New York; 278 pp. with 91 figs; $3.50.

This excellent treatise deals with those aspects of chemical engineering that involve the interphase diffusion of material, phenomena that are associated with processes of absorption, extraction, drying, humidification and de-humidification. Of these, the first two, absorption and extraction, are of major importance in the oil industry; they underlie such operations as fractional distillation and solvent refining, and it will displease no petroleum technologist to find that the author gives particular attention to engineering problems connected with the design and operation of equipment for absorption and extraction.

The subject matter is provided with a solid theoretical background which presents the important relations derived from the kinetic theory and explains their applicability to the interphase transfer of materials. Graphical methods for design calculations are freely used, and a chapter is devoted to the design of absorption equipment for multi-component systems; this is a subject of decided importance in the petroleum industry, and the author enriches it with tables of previously unpublished equilibrium data. The principal types of absorption equipment are described, and absorption co-efficients for the various systems are presented. The final chapter deals with the underlying principles of solvent extraction—again a matter of importance in oil refining—and explains the general methods of calculation employed both for three-component systems and for the solvent refining of lubricating oils.

It is a book for the petroleum engineer to have and to use.

PETROLEUM SUBSTITUTES

Liquid Fuels by the Pott-Broche Process.—M. F., in REV. PETROLIFERE, 1937, No. 723, pp. 241–242.

It has lately been announced that a new process for obtaining liquid fuels from bituminous or fusible coals has been put in operation by a German corporation capitalized at 22,400,000 reichsmarks. This process is the invention of A. Pott and H. Broche; it differs from the previous methods of hydrogenizing coal in that the operation is conducted in two or more stages instead of one.

The first stage consists in separating the workable portions of the coal from the inactive portions (ash, etc.) This is accomplished by treating the coal under pressure with appropriate solvents, preferably tetraline or phenol, having boiling points above 100 deg. C. Under the influence of heat, pressure and the action of the solvent the coal is largely "solubilized", so that above 70 percent of its weight is obtained as a liquid phase. The unsolubilized materials are then removed by filtration or centrifugaling. An important point in this connection is that coals contain a variety of substances, some of which are more readily destroyed by heat than others. In one form of the Pott-Broche process, therefore, the first or solubilizing process is carried out in stages designed to make progressive fractional separations of the different groups of constituents. With this idea in view the temperature of the first extraction is 320 deg. C. The unsolubilized residue from this extraction is then treated with a fresh portion of solvent at a higher temperature (350 deg. C.), while the liquid portion of the first extraction is used to digest a fresh portion of coal at 320 deg. A third extraction is made at 380 deg. C. and a fourth at 400 deg. This whole extraction process is therefore conducted on the familiar counter-current principle used in many other chemical processes.

The end result of the extraction is a pitch-like substance free from solid or inert constituents; after removal of the solvent this pitch melts at about 100 deg. C., so that it can be converted by heat into a liquid that is well adapted to the second, or hydrogenation, stage of the process. The hydrogenation is accomplished under appropriate conditions of temperature, and with a suitable catalyst, these two factors being combined so as to result in the greatest proportion of low boiling hydrocarbons. A preferred catalyst is one that will act as a "dissociant", tending to break up large molecules into small ones; still better is a catalyst that will combine dissociation with hydrogenation. This requirement rules out molybdenum, which has been favored in some coal hydrogenizing processes, but magnesium chloride, ferric chloride and copper chloride have given good results.

It has also been found advantageous to effect the hydrogenizing in two stages, first a hydrogenation stage at moderate temperatures, using a catalyzer—the action of which is principally the addition of hydrogen to unsaturated compounds; the products of this stage are largely high-boiling hydrocarbons. Then these products are subjected at higher temperatures to the action of "dissociation" catalyzers to produce low-boiling substances (catalytic cracking). For hydrogenizing purposes it is possible to use a gas containing less than 80 percent of hydrogen, even coke furnace gas and illuminating gas. In this way the extract is made to furnish about half its weight

in light-boiling liquid fuels; 1,000 kilograms of coal yield from 700 to 900 kilograms of extract.

At this writing it appears certain that the Pott-Broche process will cause present methods of coal hydrogenation to be extensively modified.

Future of Alcohol Admixture in Germany.—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 4 (1937), No. 8, pp. 89–90.

The policy of enforced mixing of alcohol with gasoline, which was adopted by Germany as an aid to potato farmers, is now facing some hard facts. As is well known, Germany is struggling with underproduction of food crops on the one hand, and on the other with a shortage of foreign exchange with which to finance imports of food materials. Under such circumstances, the diversion of large quantities of an essential food crop to non-food purposes has become a social-economic absurdity. It is now announced that the production of alcohol from potatoes is to be radically restricted; food will no longer be "degraded to a fuel". Many of the hundreds of potato distilleries must discontinue operations. In proportion as ethyl alcohol recedes from the picture the producers of methanol, which is mostly a product of coal hydrogenation, are aiming at increasing their sales for motor fuel purposes, while the young industry of alcohol distillation from wood is also trying to enlarge its market. These two interests, therefore, will try their utmost to ensure that the 10 percent admixture is maintained in full, in spite of the fact that the measure was originally introduced for the express purpose of assisting potato growers. From being a subsidy for German agriculture, compulsory admixture, if continued, will thus become in due course a subsidy for the German methanol producers, to whom it means a price and sales guarantee which they would not otherwise have.

PETROLEUM ECONOMICS

Lubricating Oil Markets and Trade Revival.—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 4 (1937), No. 7, pp. 73–76.

Last year saw a marked improvement in the lubricating oil business. Output and demand continued to rise, and world market quotations registered some recovery. In this field the oil industry is shaking off the adverse effects of the crisis, though it has not yet succeeded in reaching the peak of pre-depression times in either production, demand or proceeds.

Sales of lubricating oils naturally suffered more during the crisis in those industries and traffic enterprises which were badly hit than in those which were less sensitive to economic changes. Similarly, recovery in demand has been most marked in those spheres where industrial revival has been strongest. On the whole it can be said that the decrease in demand for lubricating oils during the period of economic depression was much more pronounced than the recovery brought about by the subsequent trade revival.

This statement may seem at first somewhat astonishing. In 1936 industrial world production nearly reached its pre-crisis level, and in many countries considerably surpassed it. Motor transport exceeds all previous dimensions, world shipping has experienced a revival, and air traffic has developed by leaps and bounds. If one further takes into consideration that during the past few years numerous new industries have come into existence and that re-armament programmes have in many countries resulted in an increase in industrial activity, it would be reasonable to suppose that the demand for lubricants would have increased to an extent corresponding to the expansion of industrial production and the revival in all branches of traffic. This, however, is not the case. World consumption of lubricants during 1936 was appreciably below that of 1929.

The fact that lubricating oils did not participate fully in the general increase in the demand for oil products may be explained primarily by greater economy in consumption, due largely to the improvement in lubricating oil qualities. In connection with technical advance in machinery and motor engine design, the question of economy in the use of lubricating oil has always been an important consideration, and the oil industry has endeavored, not only to comply with the demands of the technicians, but to improve the quality of its lubricants by adopting new and improved working processes. Each improvement in quality means increased economy in consumption, and the progress which has been found possible in this direction can be seen from the fact that whereas in America a few years ago the proportion of lubricating oil to gasoline consumption in motor vehicles was 6 percent, to-day the proportion is only 1.5 percent, and one may fairly assume that there are numerous other industries in which a similar economy has been possible.

The American Petroleum Industry.—Joseph E. Pogue, in BULL. AMER. ASSOC. PETROL. GEOLOGISTS, vol. 21 (1937), No. 2, pp. 149–196.

The petroleum industry is marked by two features which, while not lacking in other industries, are nevertheless not so thoroughly developed elsewhere. These special characteristics are: a vertical structure that involves an integration of activities from the raw material to the ultimate consumer; and the presence of an essential function, discovery, that must operate far in advance of the production of the raw material. The petroleum industry, therefore, rests upon the coördinated operation of five sequential fields of activity—search, production, transportation, manufacturing, and distribution—each unique and specialized, and all directed and adjusted by the economic forces that surround this complex of activities. The petroleum industry in the United States is also distinguished from this field of enterprise in most other countries by the prevalence of oil fields of subdivided ownership: this circumstance gives rise to an uneconomic phase of interlease competition which constitutes a handicap that the industry has not yet eradicated.

The purpose of the paper is to attempt to set forth the economic forces that activate the American petroleum industry, to appraise their effectiveness and limitations, and to outline the functional changes that are taking place in this field of enterprise.

The author goes on to say that the oil business in the United States is the first great industry to develop a new method of conducting its business, having altered the design of its economic structure in order to make the enterprise more susceptible to regulation by the ordinary laws of economics and to free it from the disturbing influences of the unchecked operation of the rule of capture. The industry is experimenting with a new economic form. The further evolution of proration will afford a fascinating case history of an effort by competitive enterprise, with our existing legal background, to find a practical solution for a complicated problem of unique character. Much progress has already been registered toward a workable answer. The undertaking deserves the interested attention of all concerned.

(Note.—In comparison with the world-wide sugar business, the oil industry has still a long way to go toward integration and proration. Ed.)

Smudge Oil for Citrus Groves.—Anon., in PETROLEUM WORLD, vol. 34 (1937), No. 2, pp. 38–39.

The winter of 1937 in southern California made a record as the coldest in 25 years and is remarkable for the vast quantities of smudge oil burned in an effort to circumvent extensive frost damage to the local citrus groves. During the period of threatened frost it is stated that the number of orchard heaters in operation was no less than 19,000,000. This may or may not be an exaggeration but the extent of the operations is indicated by the fact the smudge blotted out the light of the sun over an area of hundreds of square miles, requiring extensive measures to protect household effects and merchandise against damage from soot. Shipments of oil to the threatened districts at one time averaged more than 700 tank cars daily. One major oil company alone is said to have supplied more than 25,000,000 gallons to the fruit growers. Facilities for truck distribution were severely taxed.

As a result of this year's experience it is expected that there will be a great increase of oil storage facilities on the fruit ranches. The present standard grade of smudge oil is somewhat expensive, and experiments have been made with a view of supplanting it with butane. Transport and storage of butane involve hazards with which growers are not very familiar, but trials so far made indicate that better results at less cost are obtained.

Stabilization of Iraq Crude Oil Before Piping.—Anon., WORLD PETROLEUM, vol. 8 (1937), No. 2, pp. 67–72.

This paper is an official release of the Iraq Petroleum Co. It gives a fairly detailed account of the new stabilization plant at Kirkuk, in which the crude oil of this field is treated before starting on the long journey through the double pipeline to Tripoli and Haifa on the Mediterranean coast. The plant is unique in that it appears to be the only case where the crude is first treated to remove condensible hydrocarbons which are later returned to the topped crude for the pipeline transport. The crude oil therefore arrives at the pipeline terminal free from dissolved methane and ethane, but with practically all the propane and butane; the elimination of hydrogen sulphide is also practically complete. As a result, the refineries receiving Iraq crude obtain an oil richer in valuable light fractions and one that is less liable to cause corrosion of plant or equipment, or to occasion pollution of the atmosphere.

The plant consists of two units with a third as stand-by, each capable of handling 40,000 bbl. a day. The stabilization is effected in two stages. The undesirable constituents (methane, ethane, hydrogen sulphide, etc.) are eliminated in the first stage, and there is effected a light topping of the crude and a partial fractionation of the light distillates; the second stage fractionates the light distillate and the vent gas from the first stage. The topped crude from the first stage and the stabilized light distillate are then blended together for delivery to the pipeline.

GENERAL

Boiler Feed Water Level Control.—J. A. Campbell, in REFINER, vol. 16 (1937), No. 2, pp. 60–65.

In view of the inconveniences of fluctuating water-level in steam boilers used in various operations in the petroleum industry, the author has developed a new mechanism that can be adjusted to maintain the water level within a variation of one-half inch. Wet steam for distillation purposes is avoided. Besides its use in boiler-feed regulation the device is being successfully used for discharging condensed steam from evaporator and stabilizer reboilers. The condensate is discharged at a rate equal to that of formation and

no steam blows through. It can also be used for liquid-level control in any location where there is a hot gaseous component above the liquid capable of heating the upper end of the working tube. It is especially suitable for maintaining a level in stabilizers and reboilers. In one form it is applied to the control of the gas fire under a small retort in a continuous oil re-conditioning plant.

Plug-back Work More Effective with New Cements.—Mitchell Tucker, in OIL & GAS JOUR., vol. 35 (1937), No. 40, pp. 51–52.

The fact that daily salt-water production in the East Texas field is steadily increasing has presented the operators in that field with three alternatives: (1) reduce oil allowables in proportion to the increasing water withdrawal, (2) return a volume of water to the sand equal to the daily water withdrawal, or (3) reduce the daily salt-water production or at least check its steady increase. Obviously, the first alternative is highly undesirable, the second involves negotiation and cooperative experimental work and promises no immediate relief; as regards the third, a sufficient number of experimental jobs has been completed to indicate that highly successful results can be expected from plug-back or "squeeze" work, when properly applied in a well that has even a very thin section of saturated sand above the water oil contact. In such cases a cement retainer is placed at the desired point and cement applied under pressures of up to 4,000 lbs. to force the cement into the formation and thus shut out the water, the retainer being subsequently removed and the well cleaned as usual. The novelty of the method consists not so much in the plugging-back operation, which is familiar enough, but in the use of the newer cements that have physical properties particularly suitable for this type of work.

By reason of their high degree of grain fineness, and gel-like consistency, these oil-well cements do not separate out from their water; a retarded setting action is afforded to permit longer pumping times, with greater pump ability, at higher pressures; and a deeper channeling or penetration of the cement into the formation is assured.

A cement slurry of from 14 to 16 lbs. per gallon is pumpable with these cements without sacrifice of other desirable properties, and the contamination with either mud or water is negligible.

Gas-Oil Ratio as a Factor in Allocating Production.—Mitchell Tucker, in OIL & GAS JOUR., vol. 35 (1937), No. 40, pp. 27–28.

The Rodessa field has provided the industry with a very excellent example of how the injection of a proper gas-oil ratio factor in the allocation of production will result in conservation of natural gas and reservoir energy.

A few months ago, while the allowables for that field were upon a per-well basis, the daily gas wastage at Rodessa was estimated above 600,000,000 ft., or half the daily domestic consumption of the United States. On January 1, 1937, the field allowable was reallocated upon a 50 percent acreage and 50 percent bottom-hole pressure basis, with a gas limit factor of 2,000 ft. of gas to one bbl. of oil. In this same order all wells termed "gas-distillate wells" were reclassified as gas wells. As a result, the gas withdrawal has been reduced about 90 percent, and the wastage to practically nothing.

The rule applied by Section VII of the Louisiana Dept. of Conservation Order No. 7 to the Louisiana side of the field reads as follows:

"The gas-oil ratio of each oil well shall be kept as low as possible, but in no event shall an oil well be permitted to produce gas in excess of 2,000 ft. per barrel of oil produced, provided, however, that if any well which, by reason of its location or manner of completion, produces oil with a gas-oil ratio in excess of that authorized, same shall be allowed to produce daily a total volume of gas equivalent to the volume obtained by multiplying the daily oil allowable of said well, (base allowable), provided the resultant gas-oil ratio does not exceed that prescribed in Section XIV."

This latter section provides for the reclassification of all wells as gas wells that waste, burn, or blow into the air an amount of gas of more value at $0.03 per thousand ft. than the market value of the oil recovered. The order further provides for monthly gas-oil ratio tests on wells having ratios in excess of 2,000 ft. per barrel.

The Texas order, included in the Oil and Gas Docket No. 120, was essentially the same and reads as follows:

"Any well producing with a gas-oil ratio in excess of 2,000 to 1 shall be allowed to produce daily only a total volume of gas equivalent to the volume obtained by multiplying the daily base oil allowable (50 percent acreage and 50 percent B.H.P.) of said well by 2,000 ft. This amount of gas will be known as 'gas limit' for oil wells."

Relative Importance of Sources of Power.—Dorsey Hager, in OIL WEEKLY, vol. 84 (1937), No. 9, p. 18.

It is interesting to note the total energy units furnished by petroleum, natural gas and natural gasoline compared to coal and to water power. This information is shown in a table where all figures have been recast in oil equivalents. The data presented are for the year 1935.

Some changes have taken place since the 1934 analysis, notably the increase in water power from 2.3 to 3.1 percent, and natural gas from 9.6 to 10.8 percent. Both coal and crude oil were off slightly in power energy. The proportion of coal dropped 1.1 percent and crude oil one percent. Crude oil produces 34.2 percent of all energy in the United States. However, natural gas, natural gasoline and crude oil combined total increased during the year from 46.1 to 46.4 percent, as compared with a decrease from 53.9 to 53.6 for coal and water power.

Another table presents the changes in energy by these products over a 15-year period. Coal alone of all the sources of energy has decreased 17 percent. How long petroleum can continue to increase is problematical. It is scarcely likely that it will increase over 15 to 20 percent more. Water power, natural gas and natural gasoline can readily double in another 15 years. Coal will probably swing back in time to become a still important source of energy, but how long it will be before that occurs is not known.

The largest percentage increase has been made by natural gasoline, which in 1935 amounted to 272 percent more than in 1921. Natural gasoline production in 1921 was 10,710,000 bbl. and was 40,000,000 bbl. in 1935, an increase of 29,300,000 bbl. In connection with this big increase it is interesting that it still accounts for only 1.4 percent of the total energy units produced in the United States. The second largest percent increase has been registered by natural gas, which is up 135 percent in the 15-year period. Water power ranks third with a jump of 130 percent, and crude oil is next with a 115-percent increase.

The three petroleum industry energy sources have increased their production a total of 522 percent during the 15-year period, or an average of 174 percent each, against the average of 7.3 for its competitors, coal and water power.

Active Carbon in the Mineral Oil Industry.—Erwin Reisemann, in OEL UND KOHLE, vol. 13 (1937), No. 5, pp. 107–112.

Activated carbon is used in the mineral oil industry as a decolorizer and as an adsorbent for hydrocarbons that are mostly in a gaseous form at ordinary temperatures. Its use for either of these purposes in the United States is not very extensive for various reasons. In the first place, the cheaper grades of oil products can be satisfactorily treated with ordinary fullers' earth. In the second place, the adsorption of light hydrocarbons (as in the treatment of casing-head gas) involves a somewhat bothersome cycle of adsorption, steam treatment and redrying the carbon. For this reason the Americans prefer compressing and "washing" the gas with an absorbing oil, which it seems does not recover all possible value. In Germany it is imperative, from the national economic standpoint, to recover the entire quantity of condensible hydrocarbons present in the native petroleum, and this is now being most successfully accomplished by means of activated carbon; very efficient plants and processes have been devised for the purpose. Carbon adsorbents are also being used for recovering gasoline from waste tank and refinery gases. For this use it is first necessary to remove hydrogen sulphide from the gas, otherwise the carbon will become clogged with free sulphur. In treating gases with carbon it is also necessary to take into account the possible presence of components that have a tendency to polymerize to substances that would close the pores of the adsorbent.

In proportion as the Fischer-Tropsch process for obtaining gasoline by hydrogenation processes has developed, there has arisen the problem of treating the large volume of hydrocarbon gases that are formed in such processes. For this purpose the "Supersorbon" process, using activated carbon as the adsorbent, has been conspicuously successful.

Origin of Hydrogen Sulphide in Oil Wells.—T. L. Ginsburg, in PETROLEUM, vol. 33 (1937), No. 1, pp. 7–12.

The author was present at the outbreak of a gusher in the North-Caucasus. First the column of mud in the hole was thrown out, followed by gas and then oil; after two days water appeared with the oil. At each of these stages samples of mud, oil and water were taken and subjected to microbiological examination. The mud contained the organisms common to the river water used in drilling, but contained none of the Microspira group. However, this group was found in the oil and the connate water, from which the conclusion is drawn that these organisms were native to the oil horizons and were not derived from any surface source.

These Microspira are sulphate-reducing organisms, and their activity is held to account for the practically complete absence of sulphates from oil field waters and the presence of hydrogen sulphide and sulphur compounds in the crude petroleum.

Review of Developments at Kettleman Hills.—R. E. Collom and C. P. Watson, before Amer. Inst. Mining Metallurgical Engineers, New York, February, 1937.

The authors desire to emphasize the following facts and considerations:

(1) Subsurface pressure is dropping at an alarming rate.

(2) Pressure maintenance is essential to facilitate the flow of oil to wells.

(3) Loss of pressure not only affects the motive force but results in increased viscosity and resistance to flow.

(4) Pressure loss is largely due to excessive gas production.

(5) Low ratios are attainable.

(6) Pressure maintenance will result in higher recovery of oil.

Practically, the authors believe that unit operation is not the complete answer to proper oil-field development and production. The "rule of capture" is not a law. It is a shield rather than a sword. Unfortunately, it is used as the shield of greed; the antithesis of cooperative effort. When it is finally recognized that the energy of a pool as well as its valuable contents are the common property of all and that no single individual may so use his property as to injure his neighbor, then, perhaps, relief may be found in the courts for such a situation as is here shown to exist.

SPAIN'S PETROLEUM MONOPOLY

(Continued from page 45)

line. In the nationalistic territories it is supervised by special committees. During the first days of the revolution practically all motor cars, trucks, omnibuses, and even motorcycles were confiscated for military purposes. As would be expected, rough and careless treatment by inexperienced drivers has long since made most of them unfit for use. Owing to the emergency conditions brought on by the war, property and civil rights of individuals are given scant consideration. With few exceptions, cars were not returned to their owners after the confusion of the first days of the revolution even in the fascist territory. In general, a doctor may keep his car if he works for the authorities, but hardly just for his private practice. Diplomats from other countries, of course, have been allowed to retain their cars. The other cases where cars have not been confiscated, both on the red and white sides, are rare exceptions.

It is difficult for the red forces to obtain sufficient quantities of petroleum products because the nationalists more or less control the sea. The nationalists, though, while controlling the refinery on the Canary Islands, have not enough money to buy petroleum. Gasoline is therefore very scarce and it would be absolutely useless to try to buy it without a special permit granted by the authorities, and then only a small quantity at a time is allotted. In the event an owner renders some useful service with his car, the authorities provide gasoline and oil free of charge.

What is likely to be the fate of the monopoly in the event of the success of either party in the present conflict? It is quite evident that maintaining the monopoly would only be a waste of money. Gasoline distribution on a sound economic basis requires more than Spain was capable of producing even before the revolution. And now that so many of the financial and scientific leaders have been killed, the situation would be only aggravated.

It seems certain that at the end of the war the country will revert to private operation—but perhaps not to free competition. After the finish of the war the government, either red or white, will be in urgent need of money. It is quite possible that, for a considerable sum in cash, the monopoly concessions will be offered to one of the large oil companies. But then the question arises as to whether any of these companies would consider themselves wise to make such an investment, which might be lost in case of new political disturbances.

The petroleum monopoly in Spain was established under extremely favorable conditions, but this could not save it from being a first-class fiasco. Spain may be excused for its mistake, however, since the monopoly there was the first in history. It had not yet been proved how difficult it would be to realize the golden dreams of its promoters. In spite of all this there are other states which still entertain hopes of obtaining increased revenues from a petroleum monopoly. Spain's experience can hardly be said to provide much encouragement for the ultimate success of such a venture.

AMERICAN OILMEN TO WORLD CONGRESS

INTEREST in the Second World Petroleum Congress to be held in Paris June 14 to 19 this year is growing in the United States. J. Garfield Buell has been appointed chairman of a committee of Mid Continent oilmen who will journey to Paris on the French Liner, NORMANDIE, sailing from New York June 2nd to attend the Congress. This group will present an invitation to hold the Third World Petroleum Congress in Tulsa, Oklahoma. It will be remembered that the First World Petroleum Congress was held in London in 1933. Dr. Charles K. Francis has been appointed representative of the International Petroleum Exposition to the Paris Congress. The international Petroleum Exposition is an organization that stages an exhibition of petroleum equipment every two years in Tulsa. As mentioned in the March issue of WORLD PETROLEUM, Dr. Gustav Egloff will be joined by a number of distinguished petroleum engineers when he sails for Paris on June 2. Dr. Egloff has been invited to arrange the refining programme for the Congress.

$200,000 COMPETITION

ONE OF the largest scientific awards ever established has just been announced by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

In a nationwide contest open to engineers, technicians, designers and skilled workers who make any use of iron or steel in manufacture or construction, a total of $200,000 will be distributed by the Foundation through 446 prizes for technical papers. The principal winner of the competition will receive not less than $13,700, and substantial awards are provided for winning papers from eleven industrial fields.

The competition, which calls for studies on the application of arc welding to the design and construction of machinery, structures or buildings, will be conducted under the direction of Dr. E. E. Dreese, head of the department of Electrical Engineering at the Ohio State University.

Contestants, it was announced, must have their papers filed, in duplicate, with A. F. Davis, Secretary of the Foundation, P. O. Box 5728, Cleveland, Ohio, not later than June 1, 1938.

TOTAL British petroleum imports for February, 1937, amounted to 6,029,000 bbl. of which 5,397,000 bbl. were refined products. Total imports for the first two months of 1937 were 12,366,000 bbl. against 12,386,000 bbl. for the corresponding period of 1936. Crude imports for the first two months of this year were 2,092,000 bbl. against 2,334,000 bbl. in 1936.

GULF EXPORT PRICES FOR MAJOR OIL PRODUCTS

Products		Cents per Gallon			
		Feb. 17	Feb. 24	Mar. 3	Mar. 10
Gasoline:	U. S. Motor	5¾	5⅝	5¾	5⅝
	64/66–375 E.P.	6	6	6	6
	59 Octane & below	5¾	5¾	5¾	5¾
	65 Octane & above	6⅛	6⅛	6⅛	6⅛
Aviation Gasoline: (Tank-car f.o.b. Ref.)	73 Octane & above	10	10	10	10
Kerosene:	44 w.w.	5⅜	5⅜	5⅜	5⅜
	41–43 w.w.	5¼	5⅛	5⅛	5⅛
	41—43 p.w.	5	5	5	5
Gas Oil:	26–30 translucent	3¾	3¾	3¾	3¾
	30 plus translucent	4	4	4	4
Fuel Oil:	Grade C Bunker (per bbl.)	$1.00	$1.00	$1.00	$1.00
	Cargo lots (per bbl.)	.95	.95	.95	.95
	Diesel oil (per bbl.)	1.65	1.65	1.65	1.65
Lubricating Oil: (New York Export Market)	Bright Stock No. 8	29½	29½	30½	30½
	Bright Stock No. 6½	29	29	30	30
	600 Warren E.	24½	24½	24½	24½
	600 Unfiltered s.r.	22	22	22½	22½
	650 Unfiltered s.r.	23½	23½	24	24
	600 Flash s.r.	24½	24½	24½	24½
	630 Flash s.r.	25½	25½	26	26
	Neutral 200 No. 3	30	30	30	30
	Neutral 150 No. 3½	26½	26½	26½	26½
So. Texas:	Red oil 500 No. 5–6	7¼	7¼	7¼	7¼
	750	83½	8¾	8¾	8¾
	1200	8¾	8¾	8¾	8¾
	Pale oil 500	7½	7½	7½	7½
	750	8¾	8¾	8¾	8¾
	1200	9	9	9	9
Crude Oil:	East Texas crude delivered at Gulf port for export (per bbl.)	$1.45	$1.45	$1.52	$1.52
	Venezuela crude (per bbl.)	1.05	1.05	1.05	1.05
	Trinidad crude (per bbl.)	.90	.90	.90	.90
	Panuco crude (per bbl.)	1.10	1.10	1.10	1.25

U. S. S. R.

Official Figures for Soviet Oil Operations

	Crude Production (bbl.)	Daily Average (bbl.)	Runs to Stills (bbl.)	Drilling (feet)
1937				
January	16,100,000	519,355	14,750,000	480,000
February	14,600,000	521,430	12,800,000	410,000
Total 2 months 1937	30,700,000	520,340	27,550,000	890,000
Total 2 months 1936	31,444,000	524,066	26,088,700	1,026,090
Total 1936	191,911,200	507,950	171,269,500	6,952,222
Quota 1936	213,500,000	584,931	175,000,000	7,100,000
Quota 1937	241,500,000	661,644	191,500,000	8,200,000

Crude conversion: seven bbl. = one ton

THOUGH Soviet oil operators made every effort to check and repair damage done to the fields by the storms which raged over the fields in January, they were not able to accomplish much because new storms and blizzards set in at the beginning of February. Adverse weather has retarded repair operations not only in the oil fields but in other industries as well.

The oil fields of Baku, where vigorous measures were taken to clear away the destruction of the January storms, were once more harassed by storms and blizzards in February which disrupted almost all compression installations as well as a large number of wells operated by deep pumping. At the end of February more than 200 wells of those that were affected by the January storms were still out of order, in addition to the many wells which are chronically out of order. The intensity of the February storm was so great that the damage done to the fields cannot be compared to any similar experiences excepting possibly 1925 when the Soviet oil industry was still in its infancy. Almost all Baku oil field groups were affected and at some fields production fell to about 50 percent of the plan during several individual days. The total for all Baku fields at the beginning of February fell over 50,000 bbl. per day, as compared with the last days of January when production was already affected by inclement weather. Drilling operations were harassed to such an extent that on individual days only 15 percent of the plan could be accomplished and much more attention had to be given to snow removal by caterpillar tractors than to drilling.

February Daily Average Production

Major Soviet Industries	First half-month	Second half-month
Coal Production (tons per day)	347,300	353,400
Oil and gas (bbl. per day)	483,700	512,400
Coke (tons per day)	52,000	55,700
Iron ore (tons per day)	77,600	82,600
Pig iron (tons per day)	34,300	35,800
Steel (tons per day)	38,600	41,000
Rolling mills (tons per day)	30,800	32,500

From the above figures it is evident that the effects of storms and adverse weather conditions showed up in many other Soviet heavy industries besides oil. It is likewise to be seen that the damage was being gradually repaired but unfortunately at slow rate. The total coal production during February amounted to 350,300 tons per day as compared with 354,100 tons per day during January and as against 358,100 tons per day during February, 1936. Production of gas during February must have been badly handicapped as the official estimates of production indicate an average of 497,700 bbl. of crude per day for all Soviet oil fields as against 542,500 bbl. of oil and gas during January and 547,900 bbl. of oil and gas per day during February, 1936.

Total plan fulfillment for all Soviet oil fields for the month of February has amounted to between 78 and 78.5 percent, with a somewhat higher indication for the total of Baku. The individual oil field groups of Baku operated as follows (first figures = average plan fulfillment on individual days during the first half of the month, while second figures correspond to the second half of February):—Stalin fields, 78–94 percent; Molotov fields, 47–78; Kergez fields, 34–50; Lenin fields, 88–98; Kirov, 73–100; Asisbekov, 71–74; Artema, 64–81; Ordzonikidze fields, 80–104; Kaganovitch, 67–78; and Aliati fields, 71–76 percent.

Grozni oil fields show figures of 68 and 73 percent; individual Grozni oil field groups show 86–89 percent for the October fields, 14–18 percent for Daghestan fields, and 74–80 percent for Molgabek. Maikop fields show 51 percent as the lowest and 78 percent as the highest on individual days. All other Soviet oil fields outside the Caucasus show plan fulfillment as follows:

Bashkineft	52–70 percent
Embe	86–105
Voroshilov	36–65
Kalinin	69–99
Sakhalin	80–87
Turcoman	60–98

ZA INDUSTRIALIZATIU severely criticizes the Soviet oil industry for its poor showings in operation, indices for the first two months of 1937 being below plan and below the corresponding figures for the same period of 1936. During 1936, and particularly at the end of the year, Stakhanov brigades at Baku, Grozni, Maikop and Bashkiria showed their willingness to fight for oil and made fine showings in speed of drilling. The present showings for drilling are extremely poor and production is likewise lagging behind plan, as well as behind the corresponding showings of last year. So far this year no Stakhanov tempo has been developed in the oil industry at all.

The oil operators in the individual oil fields have remained most inactive and the head organization above them has remained inactive too.

Some time ago the Don coal basin opera-

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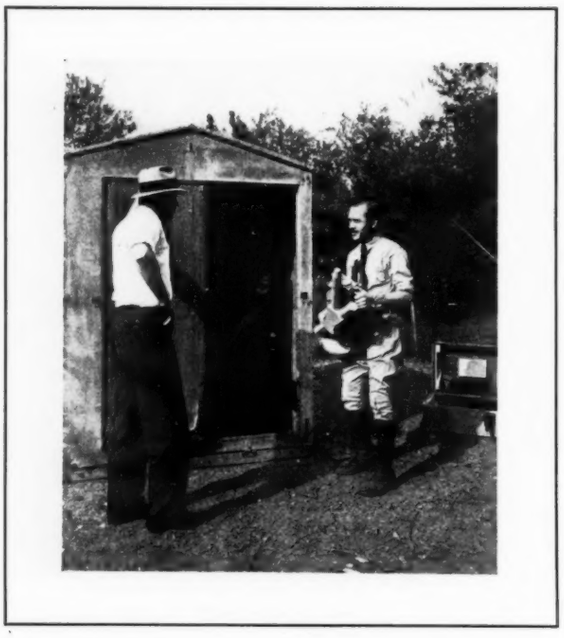
tors, criticizing such inactivity in times of adversity, sent out a call to all industrial branches of Soviet heavy industries to pull together and get busy. No response at all to this has come from the Soviet oil industry. Mr. M. Barinov, head of Glavneft, has only assured that all delegates which were sent to the oil fields have received strict orders to look into the arrears incurred and to do something in order to awaken activity. "Is this all that Mr. Barinov could do?", the paper asks, and then continues to say that if this is the best quality of management and organization the head of such an important industry is able to display, then what progress in drilling and production is to be expected? Does the top organization of the oil industry realize what it means to the entire Soviet Economy when drilling shows only 50 percent and production 75 and 80 percent plan fulfillment at its best?

A later issue of ZA INDUSTRIALIZATIU, commenting on Baku oil field operations, states that Baku shows arrears of about 63,000 bbl. of crude per day and the total arrears for the first two months of 1937 aggregate almost 3,000,000 bbl.; further, the plan fulfillment for February is below 82 percent. Almost all major oil fields of Baku are in arrears as regards new wells completed for production. At the end of February 230 wells damaged during the storms were still out of order, while at the Lenin fields 100 wells damaged were still to be put back in operation. The management of many of the major Baku fields complain of lack of hoists, but the hoists available are being utilized only at the rate of 48 percent of capacity. The liquidation of damages proceeds very slowly and production lags behind plan. Drilling is poor and in addition drilling operations are hampered by a difference of opinion which has arisen from misunderstandings between the management of drilling and the management of production. This will lead to grave results in the form of arrears unless the central authority intervenes.

In the middle of February prospecting well No. 8 drilled in Gorski mountains was opened at 3,390 ft., flowing some 2,000 to 3,500 bbl. of crude per day with potentialities of an even greater flow. The crude is of paraffin base, specific gravity 0.870. Gorski mountain is in the Terski ridge which is situated between Grozni and Maikop, about 30 kilometers from Molgabek and about 70 kilometers from Grozni. Well No. 8 is on the eastern side of the south wing of Terski ridge where the first well drilled has proved of commercial value. The northern wing of Terski ridge has been prospected at Eldarovo and Mushubiru, properties prolific in gas wells. Alongside of well No. 8 another well has been started and on the western end of the wing two more wells were started in drilling recently. All in all seven wells were started in drilling in this region during 1936. On February 22nd a well drilled on Asphalt mountain, which belongs to Maikop properties, was completed at a depth of 2,775 ft. and flowed some 3,000 bbl. per day.

These two testing wells on the territory between Grozni and Maikop are discoveries of invaluable importance as they are certain to open new lands for Grozni production, which has declined steadily since 1931.

The Volga-Moscow canal, which is to be opened on May 1st of this year, is preparing to open its gates for the flow of water from the Volga River. As of today 50 installations on this enterprise are yet to be completed, which are the main Volga concrete dam, seven locks, five pumping stations, various gates and so forth. Some of the pumping stations have already been tested and the propeller aggregates are reported to operate satisfactorily. The assembling of the hydro-electric installations is now proceeding under full speed and similar progress is reported in regard to signalization, automatic control and telephone installations. With the opening of this canal on May 1st Moscow will become the terminal of a waterway from the Caspian Sea. Any sea craft navigating the Volga bound for Moscow and entering the Moscow River will have to pass nine locks and 11 dams, flow over two tunnels, pass under bridge structures of five railroads and 10 highways, and in order to do so will be assisted by five pumping stations operated by seven hydro-electric power plants. Only 16 kilometers of the total 12[illegible] kilometers of the canal can be used for navigation freely without locks. At the Ivanovski water basin the total spread of the water between shores reaches some [illegible] kilometers and the depth varies between 5 and 57 ft., and navigation will require automatically lighted buoys. Between Ma[illegible]



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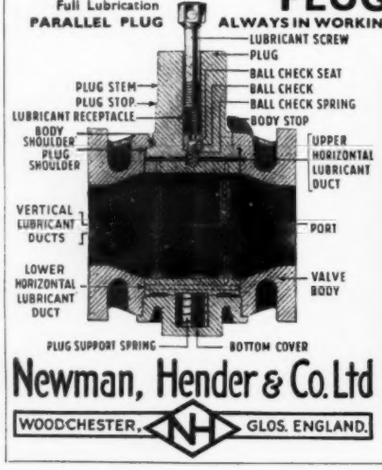

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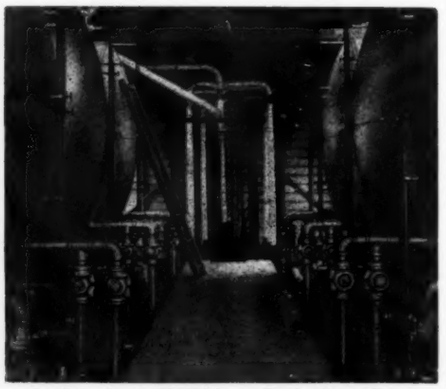


Installation showing N-M Valves on Gasoline Storage Tanks

1st and the end of 1937 a total of 971,000 tons of freight are to be carried over the canal, a total of 112,000,000 kilometer tons. When the Volga-Don canal is completed the freight capacity of this waterway will be 15,000,000 tons and will be of importance for the transportation of oil.

In addition to, and in connection with this waterway another huge project called The Greater Volga Enterprise is planned. This is a part of the so-called reconstruction of the country at large. Greater Volga contemplates the erection of a number of gigantic hydro-electric power plants to link up by waterway the northern part of the country with the southern sea outlets. In addition, it is planned to irrigate large dry areas along the Volga shores. Between Rybinsk and Stalingrad, over a distance of about 500 kilometers, several dams are to be erected between 70 and 100 ft. high to form deep and slowly flowing water basins. All in all six hydro-electric power plants are to be erected at Rybinsk (near Gorki), at Samarski Luka, at Kamishin and at Stalingrad, which will have an aggregate capacity of 8,000,000 KW. to generate some 40,000,000,000 KWH. per year—in addition to which hydro-electric power plants will be erected on the Kama River with a capacity of 2,000,000 KW. or 11,000,000,000 KWH. per year. The total of about 50,000,000,000 KWH. represents the equivalent of 25,000,000 tons of fuel produced in these localities in the form of peat, lignite and shale. Total Soviet production of coal in 1936 amounted to 75,000,000 tons in the Don coal basin, 17,000,000 tons in the Kuznetzk basin, and 7,500,000 tons in the Moscow region. The power plants of the Volga and Kama will be connected by high-voltage lines cross country with power-plants on the Dnepr river in the west and Northern Caucasus and the Don basin system in the south.

The Volga-Kama water system, with an

Soviet Oil Exports—January, 1937

	Quantity (tons)	Value (Rbl.)
Crude oil	40,408	1,455,000
Gasoline	35,656	3,462,000
Kerosene	24,447	1,727,000
Lube oil	24,187	2,983,000
Gas oil	33,736	1,788,000
Diesel oil	579	19,000
Fuel oil	61,766	2,080,000
Asphalt, Pitch & Coke	105	6,000
Total	220,884	13,520,000
Total January 1936	249,222	13,346,000

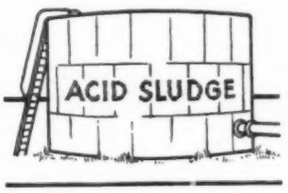
By Countries

Japan	40,367	1,453,000
Spain	29,615	2,224,000
England	25,689	1,994,000
France	18,741	1,419,000
Italy	11,772	396,000
Sweden	11,211	699,000
Denmark	11,155	902,000
Germany	9,078	895,000
Iran	3,621	212,000
Switzerland	1,559	122,000
Finland	1,451	116,000
Belgium-Luxemburg	1,085	303,000
Afghanistan	421	86,000
Esthonia	257	20,000
West China	227	46,000
Lithuania	156	11,000
Mongolia	103	18,000
All others	54,376	2,584,000

What quality of acid can you recover from the contents of this tank?

With Sludge Separation

Only weak dirty acid that cannot be purified economically and must be put through an additional concentrating operation before usable. A large percentage of acid is lost in each of these operations.



With a CHEMICO Sludge Conversion Plant

Clean strong acid, continuously regenerated at low cost with high percentage recovery. This plant is operated by ordinary labor and at minimum attendance cost.

IN view of the processing economies and low refining costs essential to profit under today's competitive conditions, what justification can there be for continuing any practice of acid sludge disposal that discards recoverable value or imposes excessive handling expense?

The CHEMICO Acid Sludge Conversion Process

substitutes savings for disposal losses, provides the refinery with clear clean strong acid, and effects important economies wherever the acid requirement exceeds 20 tons per day.

In this CHEMICO process the raw untreated sludge is decomposed into strong sulphur dioxide gas and dry granular coke. The gas after scrubbing and extraction of the oil content is converted into 98% or stronger acid in an acid production unit. Part of the coke residue is used for decomposing the sludge, and the rest is excellent fuel for other uses. Nothing remains for disposal and no fumes escape. There is no economic loss, and the pollution problem is eliminated. Centralized control makes the labor expense very low.

By this process acid of any strength may be produced economically even from acid sludges which are unsuitable for utilization by any other method. The regenerated acid requires neither concentration nor purification.

Every CHEMICO Sludge Conversion Plant is designed specifically for the conditions in the refinery it serves, and performance is definitely guaranteed. CHEMICO assumes complete responsibility for plant design and erection, choice and installation of equipment, and trains the operating crew. The plant is delivered ready for operation with acceptance asked only after proof, by a test run, that the guarantees are met.

Contracts are usually based upon lump-sum payment to cover everything, including consultation, preliminary experimentation (when necessary), patent license, design, erection, installation and initial operating supervision.

The first CHEMICO Sludge Conversion Plant, built in 1932, operates constantly at higher average than its rated capacity of 50 tons of fuming acid per day, and has proven highly satisfactory. Three installations now under construction include one for a prominent foreign refiner.

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average depth of 20–23 ft., is certain to provide sufficient draft for sea-going vessels to land at Moscow and, connected with the Sheksna and Vitegra, the Volga waterway will provide access to the Baltic, and, by way of the Baltic-White Sea canal, to the White Sea as well. In the south the Volga-Don and Manitch waterways will form a sufficiently deep sea outlet to the Black Sea.

Almost 90 percent of Soviet international trade is carried by sea transport, and during the 10 years between 1925 and 1935 the Soviet mercantile marine has grown from 265,000 tons of bottoms to about 1,200,000 tons. The Soviets have gradually increased tonnage by domestic building as well as by acquisition of seacraft in other countries.

During the first eight months of 1936 about 2,700,000 tons of Soviet export trade and about 515,000 tons of Soviet imports were carried between Soviet and other ports by Soviet vessels, and during the same period the Soviets chartered a total of about 4,100,000 tons of freight capacity.

Tonnage Chartered by Soviets

8 months, 1936

	No. ships	Cargo tons
Grain	29	132,200 tons
Ore	101	634,800 "
Coal	82	498,000 "
Timber	799	2,091,600 "
Petroleum	31	263,500 "
Miscellaneous	90	463,600 "
Total	1,132	4,084,600 tons

The Soviets have now centralized all chartering of vessels under the SOVFREIGHT in Moscow with arbitration of all possible disputes to be held by the Maritime Arbitration Commission at the Chamber of Commerce in Moscow. The "Red Sormovo" Shipyard has now under construction for service on the canal and Moscow 16 motor ships, of which four are for Moscow, eight are freight ships, and four are passenger boats. These passenger boats are of streamline design with all welded bodies 73 meters long and 15 meters beam, and will develop a speed of 21 kilometers per hour, having two motors of 350 h.p. each.

During the last four years the Soviets have invested for new industrial development a total capital of 96,000,000,000 Rbl. During 1937 a total of 32,500,000,000 Rbl. will be invested for industrial development. Thus the total investment of new capital during the Second Five Year Plan will amount to 128,000,000,000 Rbl. as against 50,500,000,000 Rbl. invested during the First Piatiletka. Of the total of 32,500,000,000 Rbl. to be invested in 1937, 8,440,000,000 Rbl. will be allotted for the Heavy Industries. The oil industry will receive in 1937 a total of 1,130,000,000 Rbl. to be applied mainly for drilling and erection of new refineries. About 40 percent of the above total will be used for drilling operations, with a view to drilling and to completing 3,600 wells in all Soviet oil fields during the year. The expansion of the refining industry will carry the erection of new refining capacities to a total of 14,000,000 bbl.

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